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U. S. DEPARTMENT OF AGRICULTURE.

BUREAU OF PLANT INDUSTRY—BULLETIN NO. 236.

B. T. GALLOWAY, *Chief of Bureau.*

FARM MANAGEMENT:

ORGANIZATION OF RESEARCH AND TEACHING.

BY

W. M. HAYS, ANDREW BOSS, A. D. WILSON,
AND THOMAS P. COOPER.

[In cooperation with the Minnesota Agricultural Experiment Station.]

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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Plant Industry,
Office of the Chief,
Washington, D. C., October 17, 1911.

Sir: I have the honor to transmit herewith a paper entitled "Farm Management: Organization of Research and Teaching," which is recommended for publication by the Agriculturist in Charge of Farm-Management Investigations. This paper has been prepared by Profs. W. M. Hays, Andrew Boss, A. D. Wilson, and Thomas P. Cooper and is based partly on three lines of work in the Minnesota Agricultural Experiment Station and in the Agricultural High School at University Farm, St. Paul, Minn., viz: (*a*) Investigations to determine the best methods of crop rotation for Minnesota; (*b*) investigations in the cost of producing farm products in Minnesota; and (*c*) efforts at devising methods of teaching farm organization and management, and on related work in this Department and in other experiment stations.

The effort is here made to bring together some of the results of these new lines of work that they may be useful to farmers in the management of their farms, and also that the beginning may be made at bringing the subject matter of farm management into better pedagogical form, useful in teaching farm management in the rural and higher agricultural schools. It is believed that this bulletin will serve at least as a guide, if not as a text, in teaching farm management. The teachers can follow the bulletin in everything except the plans of actual farms. The class work concerning the reorganization of the farms local to each State or lesser agricultural region can be centered about the home farms of the pupils. They can be required to make plans of their own farms as they are now managed and to devise plans for their reorganization.

Respectfully,
B. T. Galloway,
Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

CONTENTS.

Page.
- Farm management 7
  - Planning the farm and its business organization 9
  - Planning fields for the rotation of crops 11
  - The farmstead 14
  - Comparing schemes of crop rotation 18
- Rotation experiments at University Farm 20
  - Comparison of cropping systems tested 26
  - Corn grown continuously 29
  - Model rotation 30
  - The five-year rotation applied to farm conditions 34
  - Yields of corn, wheat, and hay under different systems of cropping 35
  - Profits increase more rapidly than yields 36
  - Summary of rotation experiments 36
  - Importance of grass crops 37
- The use of statistics of cost of farm products 39
- Methods of using farm-management data 41
- Farm-management investigations needed 42
  - Crop-rotation experiments needed 42
  - Cost of farm products 43
  - The value of farm products 43
  - Facts from successful farmers 44
- The teaching of farm management 44
  - Teaching farm organization in consolidated rural schools 45
  - The key-map method of organizing the farm 50
  - Teaching farm management in agricultural high schools 52
  - Complex rotations 52
- Appendix 54
  - Instructions to students 54
  - Guide for student's written statement 55
  - Farm plans made by students 58
  - Students' farm plans 60
    - Bluegrass Farm 60
      - The proposed plan 60
      - Instructor's criticism 61
    - Powell Farm 62
      - The new plan 63
      - Instructor's criticism 64
    - Keogh Farm 65
      - The new plan 65
      - Instructor's criticism 65
    - Lakeside Farm 66
      - The proposed plan 66
      - Instructor's criticism 67
    - Martinson Farm 68
      - The new plan 68
      - Instructor's criticism 69

Appendix—Continued.

Students' farm plans—Continued.

Page.
Cloverdale Farm 70
    Four-year rotation on fields G, H, I, and J 71
    Instructor's criticism 72
Skoglund Farm 72
    The new plan 73
    Instructor's criticism 73
Lake View Farm 74
    The student's plan 75
    Instructor's criticism 76
Marple Farm 77
    The new plan 77
    Instructor's criticism 77
Greaves Farm 78
    The new plan 78
    Instructor's criticism 78
Austvold Farm 79
    The new plan 80
    Instructor's criticism 81
Anthony Farm 82
    The student's plan 82
    Instructor's criticism 83
Whitney Farm 84
    The new plan 86
    Instructor's criticism 87
Anderson Farm 88
    The student's plan 88
    Instructor's criticism 88
Hathaway Farm 90
    The new plan 90
    Instructor's criticism 91
Ash Grove Farm 92
    The student's plan 92
    Instructor's criticism 93
Pomme de Terre Farm 95
    The new plan 96
    Instructor's criticism 96

ILLUSTRATIONS.

PLATES.

Page.
PLATE I. Fig. 1.—General view of rotation plats at University Farm, St. Paul, Minn. Fig. 2.—General view of model farm experiments........ 20
II. Fig. 1.—Corn on a five-year rotation plat. Fig. 2.—Shovelful of soil from the above plat........ 22
III. Fig. 1.—Corn on a plat growing corn continuously. Fig. 2.—Shovelful of soil from the above plat........ 22
IV. Fig. 1.—Vertical section of soil on plat growing corn continuously. Fig. 2.—Vertical section of soil on plat growing fodder corn on newly broken alfalfa sod........ 24
V. Fig. 1.—Vertical section of soil near corn plant growing on newly broken alfalfa sod. Fig. 2.—Timothy sod backset after producing crop of flax........ 24

TEXT FIGURES.

FIG. 1. Farmstead on east side of 160-acre farm........ 14
2. Farmstead on northeast corner of 160-acre farm........ 15
3. Farm plan, farmstead fronting east........ 16
4. Farm plan, farmstead fronting south........ 16
5. Farm plan, farmstead fronting west........ 17
6. Farm plan, farmstead fronting north........ 17
7. Arrangement of the 44 rotation plats........ 20
8. Arrangement of plats and system of cropping on the "Model Farm Rotation Experiment" plats........ 21
9. Unorganized farm; same farm reorganized........ 34
10. Another unorganized farm; same farm reorganized........ 35
11. File case for farm-management students' work........ 46
12. Spring Lawn Farm in 1901........ 47
13. Spring Lawn Farm in 1902........ 48
14. Spring Lawn Farm in 1903........ 49
15. Spring Lawn Farm. Rotation key map........ 56
16. Spring Lawn Farm. General annual ledger data by fields........ 57
17. Spring Lawn Farm. Manuring schedule........ 58
18. Bluegrass Farm. Original plan........ 61
19. Bluegrass Farm. New plan........ 62
20. Powell Farm. Original plan........ 63
21. Powell Farm. New plan........ 63
22. Keogh Farm. Original plan........ 64
23. Keogh Farm. Student's plan........ 65
24. Keogh Farm. Revised plan........ 66
25. Lakeside Farm. Original plan........ 67
26. Lakeside Farm. New plan........ 68
27. Martinson Farm. Original plan........ 69
28. Martinson Farm. Student's plan........ 69

Page.
Fig. 29. Martinson Farm. Revised plan 70
30. Cloverdale Farm. Revised plan 71
31. Skoglund Farm. Original plan 73
32. Skoglund Farm. Student's plan 74
33. Skoglund Farm. Revised plan 75
34. Lake View Farm. Reorganized plan 76
35. Marple Farm. Original plan 77
36. Marple Farm. Key map to student's plan 78
37. Greaves Farm. Original plan 79
38. Greaves Farm. Key map to student's plan 80
39. Greaves Farm. Key map to revised plan 81
40. Austvold Farm. Key map to student's plan 82
41. Anthony Farm. Original plan 83
42. Anthony Farm. Key map to student's plan 84
43. Anthony Farm. Key map to revised plan 85
44. Whitney Farm. Original plan 85
45. Whitney Farm. Key map to student's plan 86
46. Whitney Farm. Key map to revised plan 86
47. Anderson Farm. Key map to student's plan 87
48. Hathaway Farm. Original plan 90
49. Hathaway Farm. Key map to student's plan 91
50. Ash Grove Farm. Original plan in 1901 92
51. Ash Grove Farm. Transition plan in 1902 93
52. Ash Grove Farm. Transition plan in 1903 94
53. Ash Grove Farm. Transition plan in 1904 94
54. Ash Grove Farm. Key map to student's plan, 1905–1912 94
55. Ash Grove Farm. Key map to revised plan 95
56. Pomme de Terre Farm. Original plan 95
57. Pomme de Terre Farm. Key map to new plan 96

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FARM MANAGEMENT: ORGANIZATION OF RESEARCH AND TEACHING.

FARM MANAGEMENT.

The term "farm management" includes the selection, planning, organization, and development of the farm and the daily and yearly conduct of the farm business.

The necessity of knowledge, wisdom, and skill in farm management can not well be overestimated. A European agricultural society found that on many farm estates for which it kept accounts, and for each of which long experience had established true invoice valuations, the net profits were determined mainly by the individual abilities of the respective managers, the net result on the investment ranging from a profit of 12 per cent down to a loss of 3 per cent and averaging 3 per cent profit. In every farm neighborhood there are examples of men who make a marked success, others who as markedly fail, and still others of all gradations between success and failure, depending far more on the differences in men than on differences in land or in materials, or opportunities, or other conditions.

The object sought in research in farm management is to secure the elementary facts which must be utilized in organizing and conducting the business of the farm in such a way as to give the maximum of products, profits, and enjoyment to the owner and to the farm family, to supply farm products in the best way to all who need them, and gradually to increase the productivity of the soil.

The main purposes in studying farm management are to gain power to analyze the business; to devise suitable systems of cropping, economical arrangements of fields, correct adjustments of field crops to live stock; to utilize capital and labor to the best advantage; to decide upon suitable plans for keeping simple records of the leading projects on the farm; and to carry forward year by year and day by day the management of the farm and the work of farming in such a manner as to give the largest product and the greatest profit per acre and per worker, and decade by decade to increase the productivity of the soil.

An analysis of the average farm business will show it to consist of a large number of separate enterprises or projects, any one of which is a business in itself. That each of these enterprises often overlaps every other one renders the farm as a whole a complex business. Into the production of income from each of these projects there enter, inevitably, the factors of man and horse labor; of cash expenditures; of machinery values; of taxes and interest; of depreciation of soil, fences, buildings, machinery, and live stock; and of a variety of other items, any one of which may, by becoming relatively too large, cause a loss for the individual project and perhaps for the farm business as a whole.

For example, with land worth $75 per acre and wages of farm labor worth from $25 to $40 per month, the problem of making profits by raising stock is much more complicated than when land and labor were both cheap. It costs, in Minnesota, from $20 to $35 per year to feed a cow, from $8 to $12 per year to milk a cow, from $3 to $8 per year to market the product, besides care, shelter, interest on investment, and insurance against loss. This makes a charge against each cow of from $50 to $75 per year, which shows that a cow to be profitable must yield a gross product considerably above the average. Profitable yields of butter and milk are possible, but with the average cow, given average care, the margin of profit is likely to be small. To realize a safe margin of profit, as many farmers are now doing, the cows must be so bred, selected, fed, and cared for as to yield a large product, and the cost of feed and the labor required must be kept well below the value of the product. A satisfactory solution requires both a careful study of conditions and good business management. Should such study and such management be lacking, the dairy enterprise may easily suffer a loss sufficient to overbalance the entire gain produced by the general farm business of which dairy production is a part.

The investigations (*a*) in crop rotation, (*b*) in securing data on the cost of farm products, and (*c*) in devising methods of teaching farm management, which have served as the specific basis of this bulletin, are pursued in part to aid in teaching farm management and in devising such simplified methods of keeping records with the respective farm enterprises as will actually be used in carrying forward the management of the common farm.

Farm record keeping is a valuable part of farm management, but farm bookkeeping easily becomes so complicated as to be impracticable. Especially is this true on the family farm where the farmer rarely has the bookkeeping habit and does not find it easy either to put down daily a large number of facts or to get time to summarize frequently and make useful a large amount of data. Therefore the mapping system here given is an aid in devising and establishing permanent farm plans at once scientific and practicable, and also the basic form under which to arrange the leading facts which every farm manager should record concerning his fields and the crops grown on them.

Experience with many students has proven that the plan of maps presented in figures 12 to 17 and further amplified in figures 18 to 57 serve in a most efficient way both in teaching some of the basic principles of farm management and reorganization, and also in teaching simple methods of keeping the more important records of each of the leading crop projects on the farm. This plan of teaching also serves in assisting the teacher of the country-life school in getting into a vital relation with the parents and in a position often to assist in making a new business plan for a farm which is not paying well. These maps serve somewhat the same purpose in teaching farm management that geometric figures serve in teaching geometry, or that drawings of trusses and pillars serve in teaching bridge engineering.

By recording the general data as to actual yields and prices and applying the figures relating to cost as given in Table XIII in Bulletin 73 of the Bureau of Statistics of the United States Department of Agriculture and Table XIII in Bulletin 117 of the Minnesota Agricultural Experiment Station many comparisons of approximately net profits from different crops and of different rotation schemes can be figured out.

Thus a general plan is provided which the farmer can employ in making comparisons of the profits of projects within his own farm. But possibly of even more importance is the fact that the teacher of agriculture in the consolidated or other school attended by farm youth is thus supplied with formal methods of teaching farm organization and farm management, of recording the results of farm projects, and of comparing profits from the different systems of cropping and the different types of farming in the neighborhood.

PLANNING THE FARM AND ITS BUSINESS ORGANIZATION.

The primary object of farm planning is to increase profits without proportionately increasing the cost of operation. Since the cost of plowing, rent, seed, seeding, and harvesting are nearly the same for light as for heavy yields, it is plain that under favorable conditions it does not cost twice as much to produce a 50-bushel yield of oats as to produce a 25-bushel yield.

The rotation of crops is one of the simplest, least expensive, and most easily carried out of any of the suggested improvements in agriculture, and the most practical means known, under most farm conditions, of helping to maintain the soil in a high state of productivity. It is by means of the plan of crop rotation, and the plan of joining live-stock production with the cropping scheme, that most of the restoration of productivity of the soil is secured, through the grasses and other soil-building crops and through the return of farm manures to the soil. In some conditions the farm plan makes expenditures for commercial fertilizers unnecessary, but in other conditions they are very profitable, both in connection with live-stock farming, and are especially needful in systems of cropping without stock.

In planning fields take into consideration the fact that the nearly square field requires less fencing. On the other hand, that the longer the field the more easily the team work is done, and in deciding consider the number of horses used in the fields and the kinds of crops grown. For example, if a field is to be in pasture most of the time, the more nearly square form may be used, while if often plowed and cultivated there is reason for the longer form of field.

Decide upon the area of grass crops needed, as that will aid in determining the size of fields, thus assisting to decide upon the number of fields and the rotation scheme to adopt.

The change needed on most farms in a new country is to avoid growing grain and cultivated crops continuously on one part of the farm (making the soil lean in vegetable matter) and hay and pasture on another part. Alternating these three classes of crops in an efficient rotation, and thus improving the productivity of the soil, often reduces the expense of labor, as of plowing; better distributes the labor throughout the year, as by growing more crops to be fed out in winter; increases the value of products sold; returns fertility to the soil; increases the yields and enlarges the profits on all parts of the farm.

In helping students in the Minnesota School of Agriculture to make plans for the reorganization of some hundreds of farms, it has often proven unnecessary to change materially the acreages of the different classes of crops, but rather to divide the fields and rearrange the sequence of the crops already grown.

Choose rather simple rotations with few fields. Three to six year rotations prove best in Minnesota and surrounding States, as large fields are more easily worked than small fields. For certain sections rather complex field systems requiring two or more rotation schemes must be used.

Divide the tillable lands of the farm into one, two, three, or, in very rare cases into even more, sets of rotation fields, with as many fields for each rotation as there are years required for that rotation, sometimes using two or more small fields to take the place of one rotation field (see figs. 19, 21, 24, 26, 29, 30, 33, 34, 36, 38, 40, 43, 46, 47, 49, 55, and 57).

Make a special effort to plan the form of fields on broken or hilly land in such a way as to make their cultivation the most practicable, to prevent erosion, and to adapt their sizes to the desired rotations.

Arrange so that one corner of each field is as near the farmstead as may be, that men and teams may be quickly at work upon leaving the farmstead, and that time may be saved in getting stock to and from the fields for pasture, and also to avoid waste of land and fencing in long lanes.

Use fencing rather freely, even where there is much permanent pasture, so as to secure values of pasturage—as in stubble on grain fields, or from catch crops, as rape sown among wheat or turnips among flax—often purchasing cattle or sheep to make good use of these secondary crops.

PLANNING FIELDS FOR THE ROTATION OF CROPS.

Some of the most important considerations to keep in mind in designing arrangements of fields for the rotation of crops are as follows:

Make a historical sketch of the farm, showing the areas in forests, permanent pastures, permanent meadows, and orchards as they now exist; also the location of the farmstead and of the buildings, and the plan of fields and of the crops now growing or last grown. (Figs. 12, 18, 20, and 22.)

Bring as much of the farm under the rotation as possible, that on all fields grain and cultivated crops will be alternated with the meadows and pastures, so that the soil of all fields may be benefited by the growth of grass and leguminous crops.

Reclaim or subdue for field crops, in rotation, stony areas, areas in unprofitable trees, areas in which crops are often drowned out, and areas too wet to plow; these may be profitably reclaimed at what may often seem a large expense per acre as the expense of working around these obstructions is avoided.

Plan the farm before developing the farmstead, where this is practicable.

Locate the farmstead of the family-sized farm on the highway near the center of one side rather than at the corner or in the center of the farm, thus avoiding social isolation from being in the center of the farm and the economic loss from being distant from some fields by being at the corner. Thus secure the advantages of being on the highway, where more people will call, of having fields easily accessible on three sides of the farmstead for small pastures, and of having short lanes which give easy access to all fields.

Do not decide on changing the farmstead to a suitable place on the highway if too much is sacrificed, as in buildings, roads, fences, and groves, or where expensive betterments to be made do not justify discarding the old.

Make several trial sketches, showing different possible arrangements of fields and rotation schemes of the farm to be reorganized, to gain different viewpoints of the farm and the farm business, to gain practice in making the plans, and, finally, to decide on a plan at once scientific and practicable.

Spend some time in devising a suitable plan, and estimate the necessary cost of installing it in order to save useless expense in travel to and from fields, in working awkwardly shaped fields and in poorly arranged farmsteads, and in unnecessary fencing.

Consult with neighbors and with experts in the reorganization and management of farms concerning plans for revising the arrangement of the farm, farm home, and other farm structures, asking criticism of the plans under consideration. This will be both interesting and profitable.

The planning of farms centered in consolidated rural schools will be a most vital subject both from an educational standpoint and from the standpoint of improving the farming of the district.

It will bring the teacher, the pupil, and the farmer into close discussion concerning the farmer's business. It will enable the teacher to become an expert in helping to make plans for the farms in the vicinity. It will lead to discussion and library investigation by the farmers. It will arouse emulation, and eventually much definite information will accumulate from the comparisons between the clear-cut business enterprises on the various farms of the district.

Make a key map (*a*) with fields arranged for the rotations decided upon, (*b*) showing the acreage and name of each field, (*c*) stating the crops which are to appear on each field each year for as many years as are required by the longest rotation, the statement on the fields of the key map to be set ahead some years while the farm is being readjusted to the new forms of fields and the new cropping schemes, as shown in figures 19, 21, 24, and others.

Give each field a name, as *A*, *B*, *C*, or even a short distinctive proper name, as "Hill field," "End field," "Jones field."

Make a transition map for each intervening year, in which are projected the gradual changes of fences and crops until the plan projected on the key map has been perfected. (See figs. 13 and 14.)

Make a historical map annually, showing the crops grown, the yields, value, cost, net profits, and other general facts. In case two crops are grown the same year it is wise to use two maps for each year; and a blank form can be devised and a sufficient number made to last a number of years. (For example of the use of blank forms for historical farm maps, see fig. 16.)

The simple method of making a key map, supplemented with transition maps, and followed annually by a historical map, not only helps to project a good plan of arranging the farm but also serves as a basis of keeping accounts with the enterprise on each field.

The mapping of farms offers ample opportunity for the exercise of good judgment and the use of all one's knowledge regarding the farm business and is splendid as a school subject for training the mind to clear thinking as well as to give a clearer knowledge of farm management. This is true in part because it is inspirational and leads to much discussion and to contests in making plans.

Planning farms is a more comprehensive mental exercise than playing chess, which it somewhat resembles, and far more interesting, since the plan must, in a rather simple way, coordinate all parts of the farm enterprises, must be suited to the farm and the farm family, and must be practicable, so as to lead to a large net income per acre and per worker.

The experience of teachers in charge of agricultural classes proves that farm planning offers a comprehensive and interesting study. Students rooming in dormitories working on plans for the reorganization of their own home farms have been found to consult much more with each other upon this subject than upon other subjects in their school work.

The development of engineering methods of reorganizing farms and of teaching farm organization will assist extension workers to serve as efficiency farm engineers, as consulting officers, thus aiding each farmer in installing a good plan of farm layout, an efficient crop rotation scheme, and a profitable general plan, as of a union of live stock and crop farming, or as fruit and vegetable farming.

Once the general farm plans are all laid it will be necessary to make changes to meet new conditions as of markets or labor and new plans to adjust divisions of farms into two or more farms or the union of two or more farms. There will also ever be the need of working into closer details, and of adopting newly invented machines and newly devised methods.

Formal key-map plans adhered to, and the keeping of cost records which they make possible, will lead to the discovery of those field-rotation plans and general farm enterprises which do not pay and those which do pay, that the former may be eliminated and that the best of the latter may be chosen for each farm.

Clearer knowledge will lead to the adoption of sizes of farms best for the farm community, recognizing that young people are the greatest crop produced from the land; avoiding on the one hand the farm so small that the owner can not make a satisfactory family income, and on the other hand so restricting the number of family farms as to reduce an unnecessarily large part of the rural community to the status of laborers, restricting their families to the mere income of the farm laborer. Better knowledge of farm management will lead to a happy medium between the farm too small to provide for a division of labor effectively, utilizing horses and motor machinery the year round, and the farm so large that there is an undue proportion of the farm families without capital and living on the farm labor-wage basis.

The accumulation of scientific data, local as well as general, should facilitate the cooperative organization of farming under which the laborers supply part of the capital, thus sharing in profits from capital and from managerial enterprise and ability as well as receiving the price earned for labor performed. Definitely ascertained facts concerning the cost of, and profits to, the farm, from cooperation among farmers in the preparation for market and marketing of dairy products, fruits, vegetables, grains, and other products will greatly extend the cooperative doing of those parts of the farm business which can be done most effectively and most economically by collective effort.

THE FARMSTEAD.

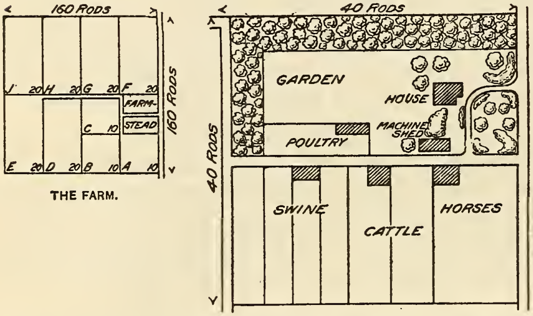


FIG. 1.—Farmstead on east side of 160-acre farm. A six-year and a three-year rotation on the farm and eight live-stock paddocks on the farmstead.

In planning a farmstead plenty of space should be included for yards, garden, orchard, grove, drives, live-stock paddocks, and similar areas.

Figure 1 shows a farmstead on the east side of a 160-acre farm, with enlarged view more in detail of the farmstead.

This farmstead occupies 10 acres of land, which is about 6 per cent of the area of the farm. For smaller farms the percentage of area may be somewhat larger and for larger farms the percentage of area may be somewhat smaller than 6 per cent. This is a rather large farmstead, but parts not at once needed for the purposes of the farmstead may be used temporarily for pasture and other crops.

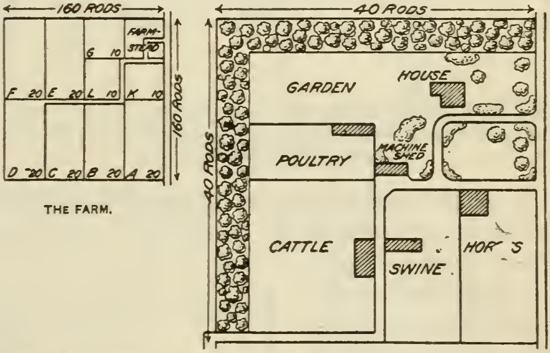
This plan, also the similar plan in figure 2 for the northeast corner of a 160-acre farm, allows a distance of 10 rods between the house and barn and proportionate distances, as shown, between the other buildings, far enough apart for security in case of fire, and yet not too far for doing chores in severe weather. They afford room for a grove 5 or more rods wide on the north and west sides, which should be provided in every prairie-district farm, and also in the northwest on every timbered-district farm.

Ample room is provided for a garden. If conditions are right orchard trees may be planted in the farmstead inclosure, or, if better conditions of air drainage be required, the orchard may be planted outside the farmstead, preferably on a hillside sloping east or northeast.

A spacious lawn is provided, and some of the leading features in the way of trees and shrubbery are roughly indicated. The large lawn and the ample live-stock paddocks near by give a broad effect to the farmstead.

A lane leading from the public highway connects the horse barn, the cattle barn, the swine barn, and also the machine shed with a lane through which each of the nine fields may be reached in the most direct manner.

There is ample room to enlarge the indicated buildings and to add others. Since most farm animals must be fed from 500 to 1,000 times each year, a slight waste of time at each feeding means a large waste in a year, or in a lifetime. A plan intelligently worked out saves this waste.



THE FARM.

FIG. 2.—Farmstead on northeast corner of 160-acre farm. Six-year and three-year rotations on nine fields; also four paddocks.

Since the farmstead is to be the permanent home of the family, too much attention can hardly be given to making it attractive and interesting, as well as healthful, comfortable, and convenient. The home builder should use the lawn as a canvas and with grass for a background use trees, shrubs, and other plants, and also buildings, to paint a picture, beautiful when viewed both from without and from within.

Trees should be so arranged as to protect from winds and storms, to provide shade, to add beauty, and to shut out undesirable views, and where practicable openings should be left so that beautiful or interesting things may be seen from the farm home.

Good drainage is one of the first essentials for a location for a farmstead. If the land is not well drained naturally, underdrainage where necessary should be provided and the ground by the buildings should be filled in so that water will run away from the buildings rather than toward them, and broad, open drains should be provided to carry the surface water away quickly.

A low, wet farmstead is unsanitary, frequently causing dangerous diseases. Moreover, there is much more labor and less pleasure in working about yards and barns which often become muddy when drainage would keep them dry.

Figures 3, 4, 5, and 6 illustrate how one general plan of farmstead may be modified so as to be conveniently connected with the fields from either of the four sides of the farm.

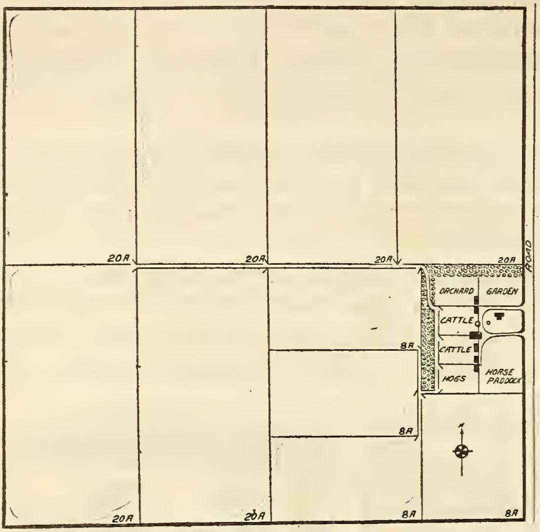


FIG. 3.—Farm plan with six 20-acre fields, four 8-acre fields, and eight acres in farmstead, fronting east.

There is great need of investigations and scientific publications presenting the general facts relating to the farmstead, with illustrations as to how best to meet the varied requirements of many farms. The special conditions as of contour, native trees, buildings, and other features already developed, and the proposed amount of present and future expenditure must all be considered. It is usually wise to remodel rather than radically to change the established farmstead and thus utilize buildings and other expensive improvements.

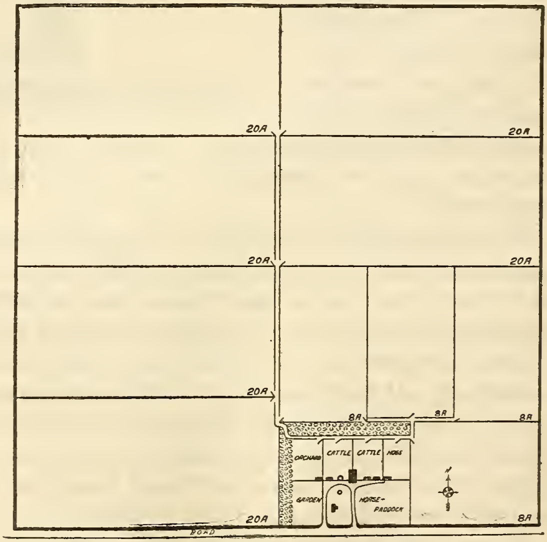


FIG. 4.—Farm plan with six 20-acre fields, four 8-acre fields, and eight acres in farmstead, fronting south.

Each plan must be worked out on the spot, using a scale map, and also stakes located so as to show the size, location, and relation of each building, and other features. Most families get great pleasure out of making a general plan and then gradually working it out as time and means allow.

As different features of the picture develop, additions may be made, often suggested by friends, who bring a new viewpoint of this utility, of that prettily planted portion of the grounds, or of some vista which should be better developed so as to add greater charm to the home.

Even in case of a farmstead already developed, which is not easy to change radically, a plan carefully worked out will be found helpful in making further developments. It is often wise thus to place on a map all the old features, that new features may then be better planned both on the map and on the grounds.

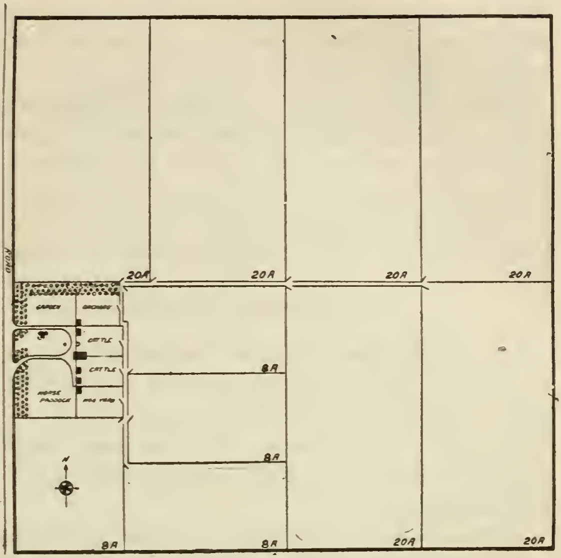


FIG. 5.—Farm plan with six 20-acre fields, four 8-acre fields, and eight acres in farmstead, fronting west.

The poultry yard may be in or near the orchard. The orchard, garden, and poultry should be placed near the house to make easy the many trips of the housekeeper. It is often wise to arrange so that the poultry can be confined to the orchard during the earlier part of the season, thus to protect the garden.

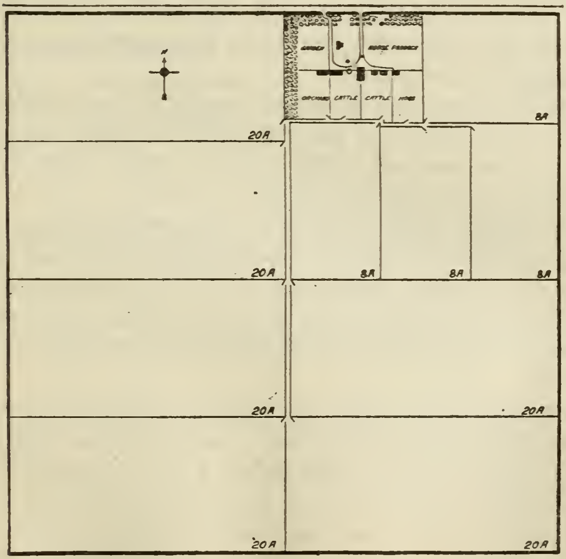


FIG. 6.—Farm plan with six 20-acre fields, four 8-acre fields, and eight acres in farmstead, fronting north.

Two good-sized cattle yards make it practicable to stack grain in one so that the straw may be converted into manure. Hogs should be placed at a considerable distance from the house to avoid the disagreeable odors which come from the pens. Good-sized hog yards should be provided in the farmstead in which some green crops may be grown, and these should be connected with the smaller fields which are devoted to raising pasture and other crops, in part to be eaten by the hogs.

Much of the grain to be used for food may be stored in the main barn. The best grain should be put in a granary where its germinating vitality will not be injured and where it can be graded that the best may be taken out for seed. This sometimes makes it desirable to have a granary separate from the main barn. Separate granaries should be convenient to the horse barn, the cattle barn, and the hog barn.

COMPARING SCHEMES OF CROP ROTATION.

One of the first and most important things to be done in laying out a system of farm management is to devise a cropping scheme which shall meet the needs of the general line of farming to be followed. This should so conserve and increase the fertility of the soil as to permanently return the largest possible net profit per acre and per farm worker.

A line of farm management research, begun in 1894, at the Minnesota Agricultural Experiment Station, is of interest in connection with the organization of farms. A series of rotation experiments designed to determine the value of various crop rotations illustrates the value of the best of such rotation schemes when compared with the usual one-crop and otherwise poorly arranged systems of farming.

The results of these experiments emphasize the effects of certain crops upon the soils in which they are grown, illustrating the relatively low productivity of soils in which there is not a fair percentage of comparatively fresh vegetable matter.

Tables I, II, III, and IV, compiled from the results of the rotation experiments, are given to illustrate the varying yields and the consequent gains or losses to be secured under good or poor cropping schemes.

Table I, showing the relative yields per acre of wheat when grown in five separate cropping schemes, illustrates the fact that the soil is prepared for each crop by the crop preceding it, by the cultivation given that crop, and by the entire series of crops in the rotation. Table II gives the yields of corn when grown under the conditions of three different rotations.

To get the average value of crops from each of the rotations given in Tables I and II, the yield of the crop grown each year was multiplied by the average farm price for December 1 for 10 years as recorded in the Yearbook of the United States Department of Agriculture, thus placing all crops on a comparable basis as to prices used in making the calculations. In case of crops for which the Department of Agriculture gives no quotations, the value per acre was determined by such current prices as could be secured.

TABLE I.—*Yields of wheat from five cropping schemes, average six years, 1899–1904.*

Year.	Wheat continuously, no manure.	Two-year rotation: Wheat and mangels, no manure.	Three-year rotation: Corn, wheat, clover, no manure.	Two-year rotation: Wheat, annual pasture, no manure.	Five-year rotation: 8 tons manure and corn, wheat, meadow, pasture, oats.
1899....bushels..	22.5	24.2	20.9	27.0	27.3
1900....do....	14.5	13.5	27.3	29.5	25.6
1901....do....	16.0	15.1	13.7	17.8	15.2
1902....do....	17.0	21.3	18.1	23.1	25.1
1903....do....	16.3	19.1	24.4	28.8	30.8
1904....do....	20.8	20.0	27.3	28.6	32.0
Average yield....do....	17.8	18.9	21.9	25.8	26.0
Average value....	$11.80	$12.41	$14.76	$16.99	$17.44
Gain in yield over continuous wheat, bushels....	....	1.1	4.1	8.0	8.2
Gain in value over continuous wheat....	....	$0.61	$2.96	$5.19	$5.64

In Table I it will be observed that the yields of wheat from these cropping systems varied from an average of 17.8 bushels per acre from continuous wheat cropping without manure to 26 bushels per acre from the 5-year rotation manured once in 5 years. Also, that each rotation system gives larger yields than does the continuous cropping to wheat. Compared with the continuous wheat cropping, the 2-year rotation (first year, wheat; second year, mangels) gave an increased yield of 1.1 bushels. The 3-year rotation (first year, corn; second year, wheat; third year, clover) gave an increased yield of 4.1 bushels. The 2-year rotation (first year, wheat; second year, annual pasture) gave an increased yield of 8 bushels; and the 5-year rotation (first year, 8 tons manure, corn; second year, wheat; third year, meadow; fourth year, pasture; and fifth year, oats) gave an increased yield of 8.2 bushels.

TABLE II.—*Comparison of yields of corn grown continuously with corn grown in three and five year rotations for five years.*[1]

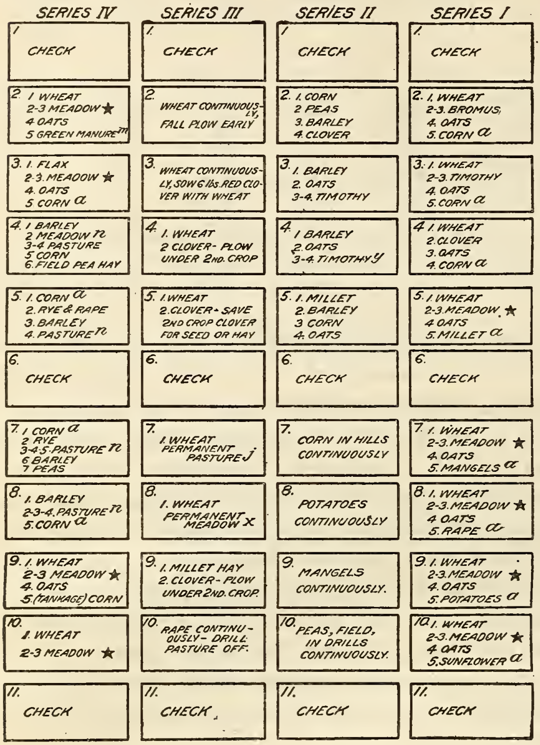
Year.	Corn continuously, no manure.	Corn in 3-year rotation: Corn, wheat, clover.	Corn in 5-year rotation: Manure, corn, wheat, meadow, pasture, oats.
1899....bushels..	20.8	51.1	31.3
1900....do....	37.5	42.6	58.0
1901....do....	13.9	42.0	42.8
1903....do....	23.6	54.7	85.3
1904....do....	11.1	45.1	37.1
Average, 5 years....do....	21.4	47.1	50.9
Average value....	$7.01	$16.11	$17.89
Gain in yield over continuous cropping....bushels..	....	25.7	29.5
Gain in value over continuous cropping....	....	$9.10	$10.88

---

[1] Record of crop of 1902 lost.

In Table II the difference in yield between corn grown continuously and corn grown in rotation is even greater than in case of the wheat. The common belief that corn does fairly well when continuously grown on the same soil without manure is not sustained by this investigation. The average difference was 25.7 bushels in favor of the 3-year rotation and 29.5 bushels in favor of the 5-year rotation. Wheat grown in rotation yielded a product worth from $0.61 to $5.64 per acre more than did wheat grown continuously on a near-by plat; and corn grown in rotation yielded from $9.10 to $10.88 per acre more than corn grown continuously.

The above are radical examples, but they illustrate most forcibly the general fact that there are wrong methods as well as right methods of cropping. The entire net profit is often lost because of wrong methods of cropping, and many farms do not pay because the arrangement of crops or their lack of arrangement in rotation is not suited to each crop, so that each and all may yield a profit.



SERIES IV	SERIES III	SERIES II	SERIES I
1 CHECK	1. CHECK	1 CHECK	1. CHECK
2 1 WHEAT 2-3 MEADOW ★ 4 OATS 5 GREEN MANURE m	2. WHEAT CONTINUOUSLY, FALL PLOW EARLY	2. 1. CORN 2 PEAS 3. BARLEY 4. CLOVER	2. 1. WHEAT 2-3. BROMUS, 4. OATS 5. CORN a
3. 1. FLAX 2-3. MEADOW ★ 4. OATS 5 CORN a	3. WHEAT CONTINUOUSLY, SOW 6 lbs. RED CLOVER WITH WHEAT	3. 1. BARLEY 2. OATS 3-4. TIMOTHY	3. 1. WHEAT 2-3. TIMOTHY 4. OATS 5. CORN a
4. 1 BARLEY 2 MEADOW n 3-4 PASTURE 5 CORN 6. FIELD PEA HAY	4. 1. WHEAT 2 CLOVER- PLOW UNDER 2ND. CROP	4. 1 BARLEY 2. OATS 3-4. TIMOTHY y	4 1. WHEAT 2. CLOVER 3. OATS 4. CORN a
5. 1. CORN a 2. RYE & RAPE 3. BARLEY 4. PASTURE n	5. 1. WHEAT 2. CLOVER - SAVE 2ND CROP CLOVER FOR SEED OR HAY	5. 1. MILLET 2. BARLEY 3 CORN 4. OATS	5. 1. WHEAT 2-3. MEADOW ★ 4 OATS 5. MILLET a
6. CHECK	6. CHECK	6. CHECK	6. CHECK
7. 1 CORN a 2 RYE 3-4-5. PASTURE n 6 BARLEY 7 PEAS	7. 1. WHEAT PERMANENT PASTURE j	7. CORN IN HILLS CONTINUOUSLY	7. 1. WHEAT 2-3. MEADOW ★ 4. OATS 5. MANGELS a
8. 1. BARLEY 2-3-4. PASTURE n 5. CORN a	8. 1. WHEAT PERMANENT MEADOW x	8. POTATOES CONTINUOUSLY	8. 1. WHEAT 2-3. MEADOW ★ 4 OATS 5. RAPE a
9. 1. WHEAT 2-3 MEADOW ★ 4. OATS 5. (TANKAGE) CORN	9. 1. MILLET HAY 2. CLOVER - PLOW UNDER 2ND. CROP.	9. MANGELS CONTINUOUSLY.	9. 1. WHEAT 2-3. MEADOW ★ 4. OATS 5. POTATOES a
10. 1. WHEAT 2-3 MEADOW ★	10. RAPE CONTINUOUSLY - DRILL: PASTURE OFF.	10. PEAS, FIELD, IN DRILLS CONTINUOUSLY.	10. 1. WHEAT 2-3. MEADOW ★ 4 OATS 5. SUNFLOWER a
11. CHECK	11. CHECK	11. CHECK	11. CHECK

FIG. 7.—Arrangement of the 44 rotation plats; also system of cropping on each plat. The plats marked check plats (1, 6, and 11 of each series) are cropped to the 5-year standard control rotation: First year, 8 tons stable manure, corn; second year, wheat; third and fourth years, meadow (timothy and clover); fifth year, oats. *Timothy, 8 pounds; red clover, 6 pounds. *a* Eight tons stable manure per acre. I, 4^2 Red clover, 8 pounds per acre. *y* Top-dress with 8 loads stable manure after cutting first crop of hay. *j* Red clover, 3 pounds; timothy, 4 pounds; redtop, 1 pound; Kentucky bluegrass, 7 pounds; orchard grass, 3 pounds; brome-grass, 2 pounds; alsike clover, 1 pound; white clover, 1 pound. *m* Plow under crop of mixed oats and millet early in summer, and late in fall a crop of rape. *n* Seed to timothy, 8 pounds; red clover, 4 pounds; alsike clover, 1 pound. *x* Red clover, 4 pounds; alsike clover, 1 pound; timothy, 4 pounds; orchard grass, 7 pounds; brome-grass, 3 pounds.

ROTATION EXPERIMENTS AT UNIVERSITY FARM.

The rotations herein discussed are on a 12-acre field of land planted as indicated in figure 7. (See also Pl. I.) These rotation plats were inaugurated in the spring of 1894 and are to continue indefinitely.

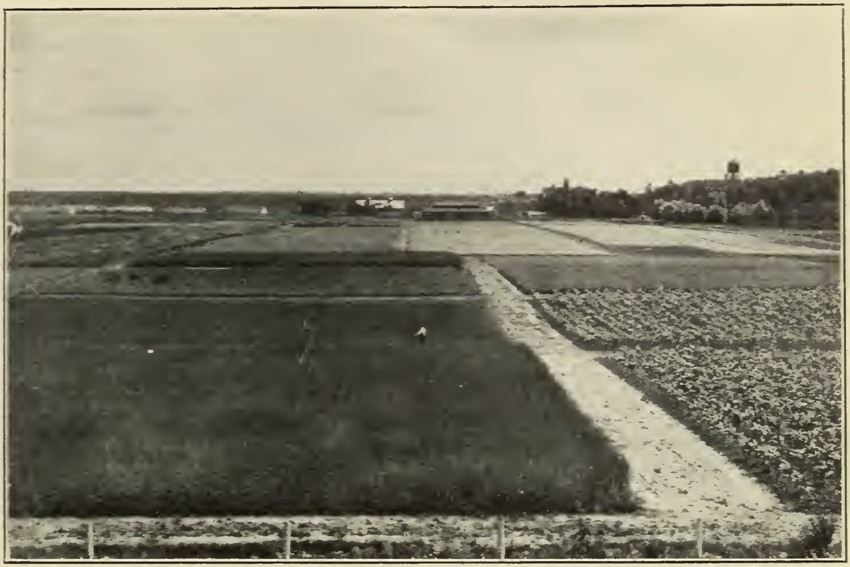


FIG. 1.—GENERAL VIEW OF ROTATION PLATS AT UNIVERSITY FARM, ST. PAUL, MINN.

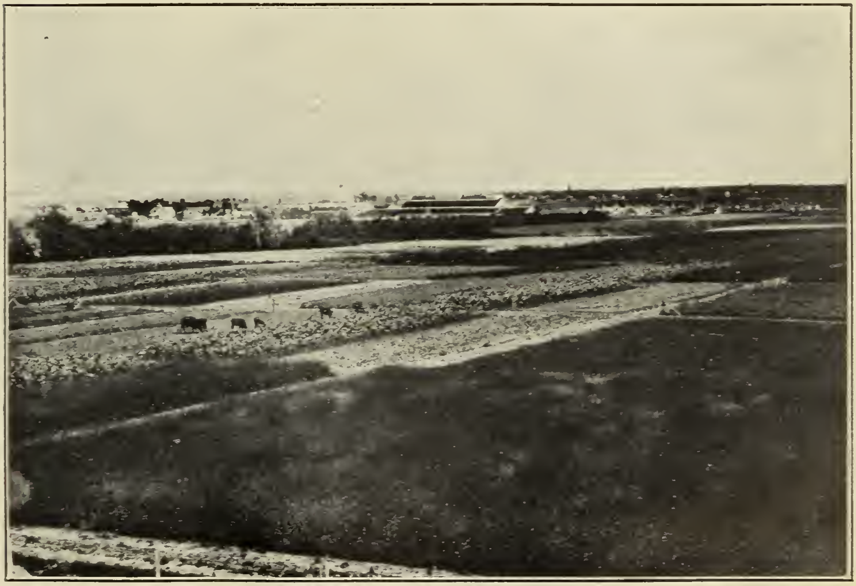


FIG. 2.—GENERAL VIEW OF MODEL FARM EXPERIMENTS.

As shown in figure 7, there are 44 plats, 11 in each of the 4 series. On plats 1, 6, and 11, of each series, marked "check" there was placed a standard rotation, which served as a basis of comparison for the intervening plats. This standard rotation covers 5 years, as follows: First year, corn; second year, wheat; third year, timothy and clover meadow; fourth year, pasture; and fifth year, oats. The practicability of this rotation is shown by the fact that in this course of cropping the land became rather more productive, the yields of crops were sustained, and an analysis of the soil in 1895 and again in 1904 showed an increase of several hundred pounds of nitrogen per acre and of a few thousand pounds of carbon per acre, thus showing an increase in the vegetable matter in the soil. (Pls. II and III.)

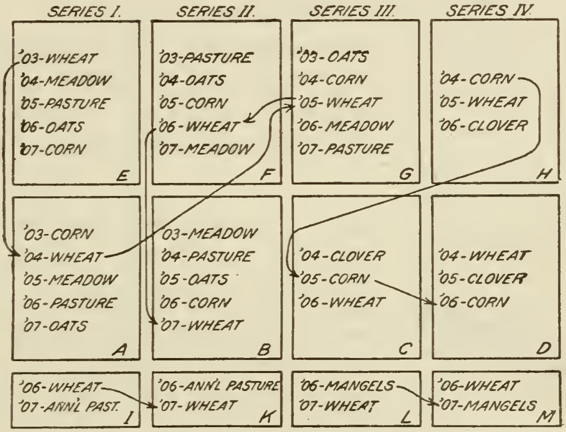


FIG. 8.—Arrangement of plats and system of cropping on the "Model Farm Rotation Experiment" plats. Sequence shown by arrows.

The annual yields of the standard rotation for the 10-year period, 1900 to 1909, were valued at $15.89 per acre while the cost was $10.02, leaving a net income of $5.87, after paying $3.50 rent and all other expenses of operation.

It is significant that this standard rotation is almost an average of 14 cropping schemes which yielded a net return of more than $5 per acre for the 10-year period, 1900 to 1909. In it are combined one cultivated crop, two grain crops, and two grass crops, making it typical of the general system of cropping which pays best in a large part of Minnesota.

TABLE III.—*Comparisons of 28 cropping schemes with the standard rotation, showing profits and losses; also gains and losses of carbon and nitrogen—experiment covering a continuous period.*

CROPPING SCHEMES YIELDING NET AVERAGE ANNUAL INCOME OF OVER $5.

Series.	Plat.	Rotation scheme.	Net profit (+) or net loss (−), 1900–1909.	Net profit (+) or net loss (−), 1895–1899.	Net profit (+) or net loss (−), 1900–1904.	Net profit (+) or net loss (−), 1905–1909.	Loss (−) or gain (+) of nitrogen, 1895–1904.	Loss (−) or gain (+) of carbon, 1895–1904.	When manured.
							Per cent.	*Per cent.*	
I	9	1, wheat; 2, 3, meadow; 4, oats; 5, potatoes	+$8.11	+$2.31	+$6.45	+$9.77	+0.008	....	1899, 1904, 1909.
IV	10	1, wheat; 2, 3, meadow	+ 7.40	+ 6.29	+ 7.68	+ 6.73	+ .011	+0.16	
IV	8	1, barley; 2, 3, 4, pasture; 5, corn	+ 6.41	+ 3.59	+ 7.02	+ 5.79	+ .016	....	1899, 1905.
III	5	1, wheat; 2, clover; save second crop clover for seed	+ 6.15	+ 7.05	+10.83	+ 1.47	+ .035	+ .31	
IV	5	1, corn; 2, rye and rape; 3, barley; 4, pasture	+ 6.03	+ 8.11	+ 4.19	+ 7.83	+ .022	....	1900, 1904, 1908.
II	3	1, barley; 2, oats; 3, 4, timothy	+ 5.97	+ 6.70	+ 6.28	+ 5.66	....	+ .11	
I	5	1, wheat; 2, 3, meadow; 4, oats; 5, millet	+ 5.91	+ 8.32	+ 7.16	+ 4.68	+ .025	....	1899, 1904, 1909.
		Standard rotation, check plats, series I, II, III, IV, plat 1, 6, 11: 1, corn; 2, wheat; 3, 4, meadow; 5, oats	**+ 5.87**	**+ 6.97**	**+ 5.88**	**+ 5.86**	**+ .015**	**+ .09**	**1899, 1904, 1909.**
II	4	1, barley; 2, oats; 3, 4, timothy	+ 5.82	+ 7.31	+ 5.31	+ 6.32	....	+ .15	
IV	3	1, flax; 2, 3, meadow; 4, oats; 5, corn	+ 5.58	+ 6.50	+ 6.77	+ 4.62	+ .014	....	1899, 1904, 1909.
III	7	1, wheat; permanent pasture	+ 5.36	+ 3.55	+ 4.75	+ 6.58	+ .004	+ .07	
IV	2	1, wheat; 2, 3, meadow; 4, oats; 5, green manure	+ 5.29	+ 8.93	+ 3.93	+ 6.67	+ .025	+ .05	
III	4	1, wheat; 2, clover; plow under second crop	+ 5.21	+ 5.63	+ 7.44	+ 2.97	+ .035	+ .31	
IV	7	1, corn; 2, rye; 3, 4, 5, pasture; 6, barley; 7, peas	+ 5.11	+ 8.14	+ 6.75	+ 3.47	+ .027	....	1901, 1908.
		CROPPING SCHEMES YIELDING NET AVERAGE ANNUAL INCOME OF OVER $3.							
IV	4	1, barley; 2, meadow; 3, 4, pasture; 5, corn; 6, field pea hay	+$5.00	+$9.14	+$4.59	+$5.54	+0.027	....	
I	10	1, wheat; 2, 3, meadow; 4, oats; 5, sunflowers	+ 4.20	+ 6.64	+ 4.08	+ 4.35	+ .005	....	1899, 1904, 1909.
I	2	1, wheat; 2, 3, bromus; 4, oats; 5, corn	+ 4.17	+ 3.11	+ 2.86	+ 5.57	+ .029	+0.06	1899, 1904, 1909.
I	3	1, wheat; 2, 3, timothy; 4, oats; 5, corn	+ 4.12	+ 4.60	+ 3.01	+ 5.24	+ .017	+ .07	1899, 1904, 1909.
III	3	Wheat continuously; sow 6 pounds red clover with wheat	+ 3.98	+ 5.18	+ 3.59	+ 4.38	+ .036	....	
I	7	1, wheat; 2, 3, meadow; 4, oats; 5, mangels	+ 3.38	+ 3.45	+ 3.59	+ 3.17	+ .003	....	1899, 1904, 1909.
III	2	Wheat continuously; fall plow early	+ 3.14	+ 4.25	+ 2.01	+ 4.27	− .028	− .32	
IV	9	1, wheat; 2, 3, meadow; 4, oats; 5, corn	+ 3.05	+ 4.86	+ 2.97	+ 3.12	+ .004	+ .18	
		CROPPING SCHEMES YIELDING NET AVERAGE ANNUAL INCOME OF LESS THAN $3.							
III	8	Wheat; permanent meadow	+$2.62	+$4.92	+$3.30	+$1.76	0.003	+0.06	
II	10	Field peas in drills continuously	+ 1.42	+ .17	− 1.81	+ 2.69	....	....	
		CROPPING SCHEMES SHOWING POSITIVE LOSS.							
II	7	Corn in hills, continuously	−$1.47	+$1.08	−$2.71	−$0.48	−0.040	−0.54	
III	9	1, millet hay; 2, clover; plow under second crop	− 2.03	− 1.70	− 2.53	− .16	+ .007	....	
III	10	Rape continuously; drill—pasture off	− 2.40	....	− 2.40	....	....	+ .10	
II	8	Potatoes continuously	− 3.17	+ 3.16	− .16	− 4.96	− .034	− .66	
II	9	Mangels continuously	−14.55	− 9.77	−12.51	−16.59	− .033	− .45	

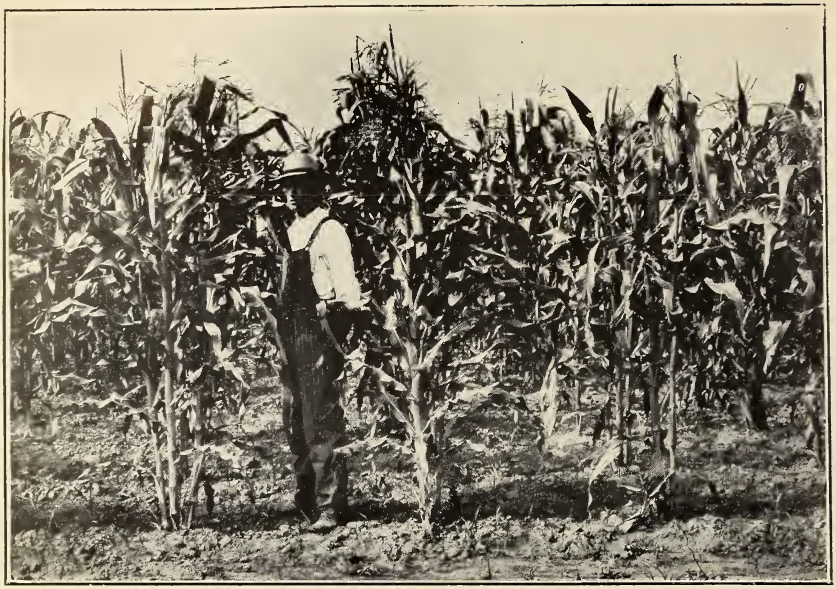


FIG. 1.—CORN ON A FIVE-YEAR ROTATION PLAT.

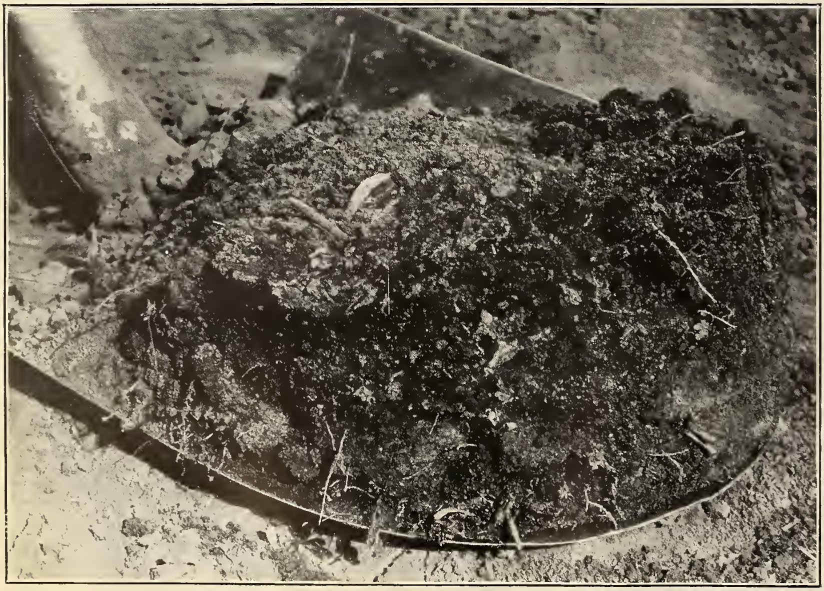


FIG. 2.—SHOVELFUL OF SOIL FROM THE ABOVE PLAT.

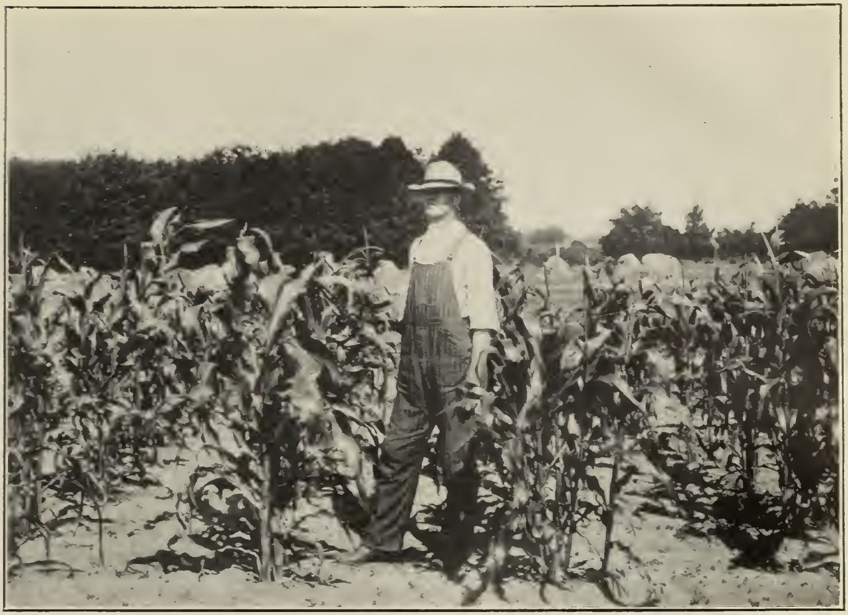


FIG. 1.—CORN ON A PLAT GROWING CORN CONTINUOUSLY.

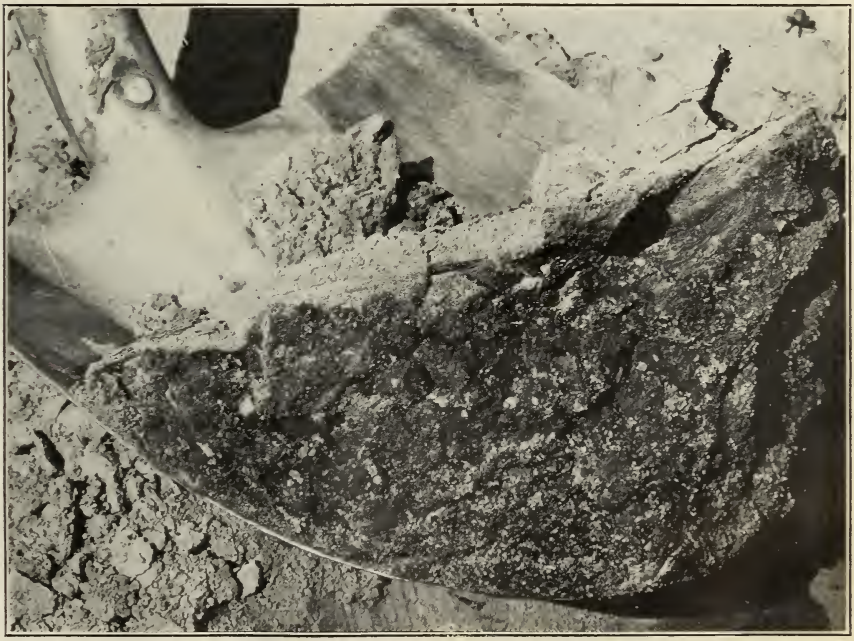


FIG. 2.—SHOVELFUL OF SOIL FROM THE ABOVE PLAT.

In Table III are given, besides the standard rotation, summary results of 28 different plans of cropping.

Some generalizations may properly be made from the results of these experiments, though the results would be very much better had land been available for as many plats for each rotation as there were years in the rotation—not only at University Farm but on three branch station farms, as designed when the experiment was begun.

All the continuously grown crops were produced at a loss, or else at from $1 to $4 less profit than the better rotations. On most of the plats bearing continuous cropping to one crop there was a loss of organic matter during the 10-year period, 1895 to 1904, as proved by the loss both of nitrogen and carbon, as shown in Table III. In cases of all rotations where grasses, cultivated crops, and grain crops were alternated, there was an increase in organic matter in the soil as shown by increases both of nitrogen and carbon, and there were also profitable crops.

The facts shown in Table III warrant the greatest emphasis being placed on the value of vegetable matter in the soil. Practically every one of the profitable rotation schemes either maintained or increased the amount of vegetable matter in the soil as shown in the last two columns of the table, and practically every unprofitable scheme decreased the total amount of vegetable matter in the soil.

Vegetable matter, in ways not yet fully understood, gives ordinary crops a wholesome condition which they require, and enables them to secure the needed food for rapid growth.

Commercial fertilizers may very often be used with profit. Their use should be more widely investigated in relation to the soils of the newer States, as well as in the older States where they are known to be profitable. Yet vegetable matter is the great fertilizer. It assists in giving to the soil a friable condition and improves the mechanical character of the subsoil. It aids the soil in retaining and giving to the crop in times of drought the needed supplies of moisture. It supplies food for soil bacteria, and partly through the agencies of these organisms and partly by the more direct action of decomposition, the soil is made wholesome and the plant food is made available to the roots of the crops.

During the millions of years in which the ordinary crop species were being developed in their wild state, they became accustomed continually to soil in which vegetable matter was abundant. By upturning the fields a goodly part of the time, thus forcing the decomposition of leaves, stems, and roots and of applied vegetable matter, the farmer greatly hastens the decomposition and removal of vegetable matter from the soil of his fields. Investigators have not been able to study out all the intricacies of the relation of vegetable matter to the wholesomeness of soil, or in regard to the wholesomeness of conditions of the soil to the roots of crops, though many interesting facts have been brought out. Common experience as well as the facts so emphatically shown in Table III dictates that the cropping and fertilizing scheme must be so arranged that there will be added, at regular and frequent intervals, considerable vegetable matter which will be going through its decomposing process while the crops are growing.

To give profitable results and at the same time to maintain or increase the productivity of the soil, a system of crop rotation must provide for the maintenance of vegetable matter, by the growing of grass crops, by the use of green manures, or by the application of barnyard manure, or by all of these means. (Pls. IV and V.)

In a general way, the scheme of the standard rotation (1 year cultivated crop, 1 year grain, 2 years grass, and 1 year grain) proved to be a good sequence of crops under which the soil is prepared for each crop by the preceding crop and also by the general system of the rotation. A study of Table III gives many facts regarding these 29 rotations.

TABLE IV.—*Comparisons of very good and very poor cropping schemes.*

Series.	Plat.	Rotation scheme.	Net profit (+) or net loss (−), 1900–1909.	Loss or gain of nitrogen, 1895–1904.	Loss or gain of carbon, 1895–1904.	When manured.
		GROUP 1.—*Very good cropping schemes.*				
				Per cent.	*Per cent.*	
I	9	1, wheat; 2, 3, meadow; 4, oats; 5, potatoes	+$8.11	+0.008	....	1899, 1904, 1909.
IV	10	1, wheat; 2, 3, meadow	+ 7.40	+ .011	+0.16	
IV	8	1, barley; 2, 3, 4, pasture; 5, corn	+ 6.41	+ .016	....	1899, 1905.
IV	5	1, corn; 2, rye and rape; 3, barley; 4, pasture	+ 6.03	+ .022	....	1900, 1904, 1908.
		Standard rotation, check plats, series I, II, III, IV, plat 1, 6, 11: 1, corn; 2, wheat; 3, 4, meadow; 5, oats	**+ 5.87**	**+ .015**	**+ .09**	**1899, 1904, 1909**
II	4	1, barley; 2, oats; 3, 4, timothy	+ 5.82	....	+ .15	
III	7	1, wheat; 2, permanent pasture	+ 5.36	+ .004	+ .07	
		GROUP 2.—*Very poor cropping schemes.*				
II	7	Corn in hills continuously	− 1.47	− .040	− .54	
III	9	1, millet hay; 2, clover; plow under second crop.	− 2.03	+ .007	....	
III	10	Rape continuously; drill; pasture off	− 2.40	....	+ .10	
II	8	Potatoes continuously	− 3.17	− .034	− .66	
II	9	Mangels continuously	−14.55	− .033	− .45	

In Table IV are separated out 7 rotations, including the standard rotation, which seem especially profitable, and 5 schemes of cropping which gave a positive loss. It can not be too much emphasized that in case of all the profitable rotations there is an increase in organic matter, while in four of the less profitable cropping schemes there is a loss of organic matter.

In Table V are presented the average value, cost, and profit of the individual kinds of crops. These averages have been made up by securing all the yields of these crops where found growing in the better cropping systems as in the best two groups of rotations in Table III.

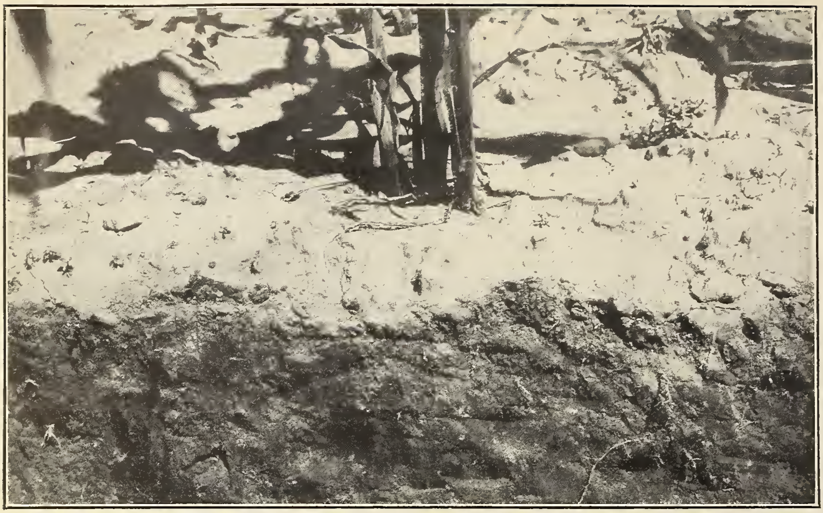


FIG. 1.—VERTICAL SECTION OF SOIL ON PLAT GROWING CORN CONTINUOUSLY.

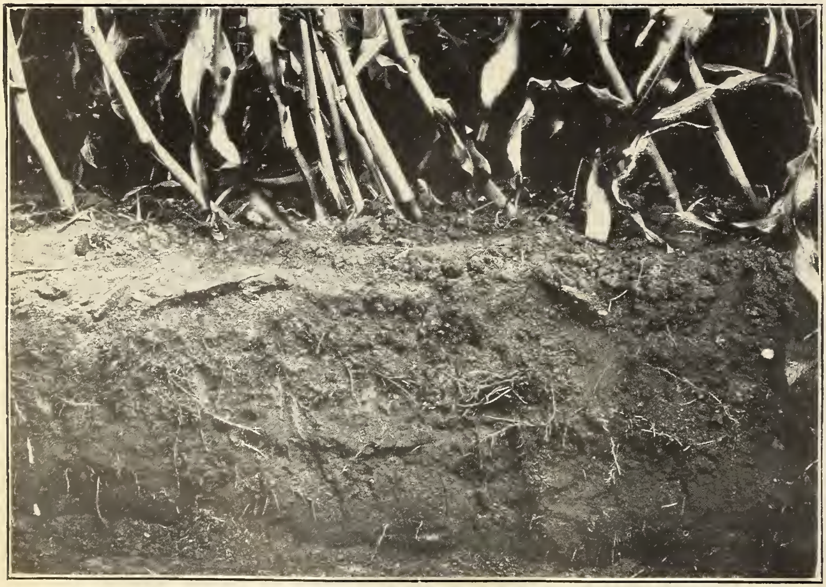


FIG. 2.—VERTICAL SECTION OF SOIL ON PLAT GROWING FODDER CORN ON NEWLY BROKEN ALFALFA SOD.

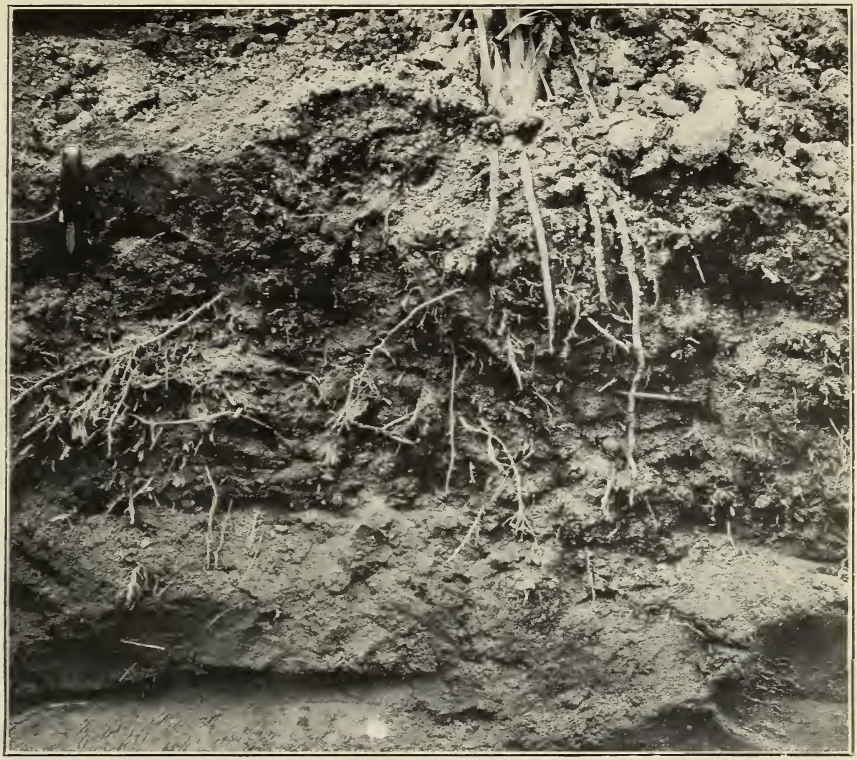


FIG. 1.—VERTICAL SECTION OF SOIL NEAR CORN PLANT GROWING ON NEWLY BROKEN ALFALFA SOD.

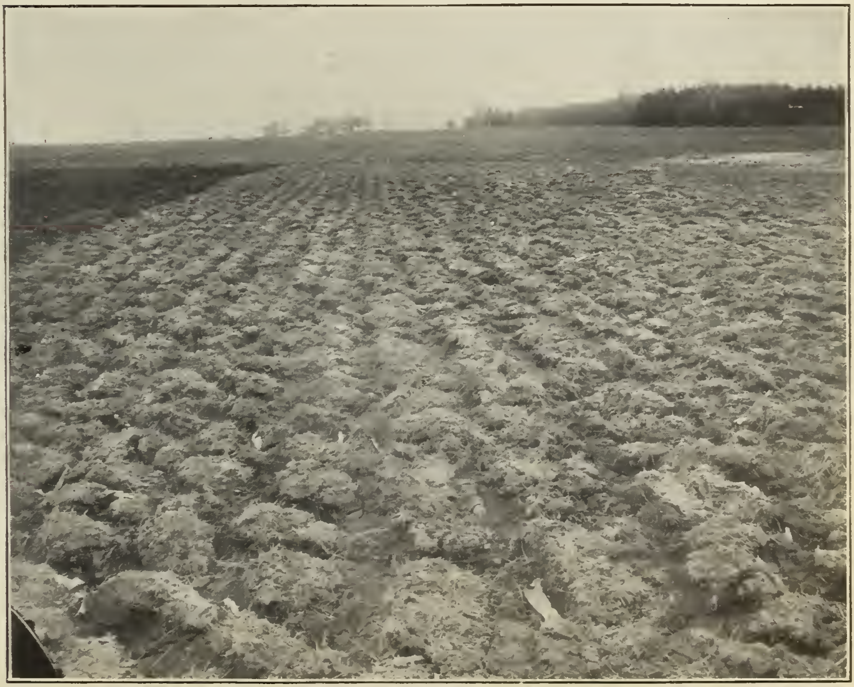


FIG. 2.—TIMOTHY SOD BACKSET AFTER PRODUCING CROP OF FLAX.

Until experiments in crop rotation have been much refined and have been continued over some decades it may be assumed that for the most part the several grain crops may be used interchangeably where grain comes in the rotation scheme. Serious effects have not been noted on the yields or profits of the crops with which they are grown, except in particular cases. Thus, in the standard 5-year rotation above mentioned, wheat, barley, rye, or flax may take the place of oats, though the wheat can not be so well substituted by other crops because it serves best as a crop with which to seed the timothy and clover for the two years of meadow and pasture. Potatoes, root crops, or other cultivated crops may take the place of the corn without injuriously affecting the yields of other crops in this or similar rotations. The timothy and red clover in the third and fourth years could be replaced by any leguminous and grass crop which would pay as well as the mixture of clover and timothy and would serve instead of these in adding nitrogen and humus to the soil.

The cropping scheme should be such as will lend itself to the use of such catch crops as rape among the wheat, oats, or barley, rape in corn, or rape following rye, all these to be pastured off in the autumn.

The following typical rotations show how these leading crops may be brought together in profitable sequence:

Three-year rotation: First year, cultivated crop, as corn; second year, grain; third year, clover or some annual leguminous crop. Rape can be sowed among the corn, and if, instead of clover, an annual leguminous crop is used, rape can be sowed among the wheat.

Four-year rotation: First year, cultivated crop; second and third years, clover and timothy; fourth year, grain; or, first year, cultivated crop; second year, annual leguminous crop; third and fourth years, grain, planting rape or turnips among the cultivated and grain crops, which here are sown in the spring.

Five-year rotation: First year, cultivated crop; second year, grain; third and fourth years, clover and timothy; fifth year, grain; plant rape among the corn or other cultivated crop the first and among the grain crop the fifth year.[1]

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[1] *The 5-year standard rotation is profitable in Minnesota.*—Table V shows that the rotation here used as the standard or basis for comparison will pay in Minnesota. The yields used are the averages of those secured on the 24 farms of which careful records have been kept in the cost-keeping investigations conducted jointly by the Minnesota Agricultural Experiment Station and the United States Department of Agriculture. The values are computed by using the average values of field crops given by the Bureau of Statistics of the United States Department of Agriculture for Minnesota. The costs per acre are those determined by the investigations above mentioned.

These farms are now farmed as well as the average of the better farms. The presence of statistical routes on these farms, providing each farmer at the end of the year with a statement of his results, has led to better methods.

But the yields would be even better had these crops been grown under as favorable rotation conditions as those provided in the 5-year scheme. The yield of $3.43 per acre in addition to paying wages to the farmer himself, a rental of $3.50 per acre, and all other expenses, is a very satisfactory return under the conditions of the broad farming in Minnesota. If this amount is reduced by $1.43 per acre, nearly half, the average farmer can still make $2 per acre above rent, all labor, and all other expenses. The State can easily average this income, and the better farmers, especially those with land of average productivity, can exceed it.

TABLE V.—*Net profit from standard rotation, based on average Minnesota yields.*

Crop.		Yield.	Value.	Cost.
Corn	bushels	35.5	$12.25	$14.28
Wheat	do	15.0	10.50	9.86
Grass	tons	1.8	9.72	6.19
Grass	do	1.8	9.72	6.19
Oats	bushels	31.3	8.45	10.69
Total			50.64	47.21
Net gain				3.43

Six-year rotation: First year, cultivated crop; second year, grain crop; third, fourth, and fifth years, grass; sixth year, grain; or, first year, cultivated crop; second year, grain crops; third and fourth years, clover and timothy; fifth and sixth years, grain; or, first year, cultivated crop; second year, grain; third and fourth years, clover and timothy; fifth year, cultivated crop; sixth year, grain, planting catch crops in the grain and corn.

Seven-year rotation: First year, cultivated crop; second year, grain crop; third, fourth, and fifth years, timothy and clover; sixth and seventh years, grain; or, first year, cultivated crop; second year, grain crop; third and fourth years, timothy and clover; fifth year, cultivated crop; sixth and seventh years, grain crops, planting catch crops wherever practicable.

Many other similar rotation combinations of these and other standard crops may be devised, and the one should be chosen which best fits the number and arrangement of fields practicable on the given farm and which so combines the best paying crops in a sequence under rotation which will give superior conditions for each and every crop and will also fit into the use of crops for live stock, such as can be economically produced with the available labor, machinery, and equipment.

The matter of using one or more rotation schemes for individual farms is amply illustrated in figures 12 to 17 (Spring Lawn Farm) and also in figures 18 to 57 (student plans).

The facts above stated, together with the facts presented in Table V, giving the value per acre, cost per acre, and the net profit per acre for the respective crops, will greatly assist the farmer in deciding on rotations and on an entire farm cropping scheme, combined with live-stock production, and on the division of his fields for one, two, or more rotation systems.

COMPARISON OF CROPPING SYSTEMS TESTED.

The results from the 44 plat tests begun in 1894 on University Farm, as shown in figure 7, during the decade 1895 to 1904, inclusive, with interpretations made possible by the exhaustive cost-keeping investigations, carried out during the same period on more than a score of practical Minnesota farms in typical regions of the State, give facts of importance in connection with the reorganization of farms. These results are such that they may well serve as an epochal mark in the organization and arrangement of Minnesota's farms, which yield profits far below those warranted by the soil and climatic conditions.

The results here reported, as of the 5-year control rotation on the 12 check plats, of $5.87 net profit per acre in addition to paying a rental of $3.50 per acre, as well as labor and all other cost, is, in itself, an inspiration. This simple, practical rotation plan is as follows: First year (8 tons barnyard manure per acre), corn; second year, wheat; third year, clover and timothy meadow; fourth year, clover and timothy pasture; fifth year, oats.

But even more inspiring is the comparison between the crops of the various cropping schemes given in Table III, and especially between the crops of the cropping schemes shown in Table IV. If the farmers of Minnesota would adopt and properly carry out some of the best of the rotations shown in Table IV their yields would be increased by $2 or more per acre above what they now secure from the often unsystematic cropping schemes irregularly carried out.

And these experiments demonstrate further, deducting a good percentage for the favorable conditions under which the crops were grown on the tenth-acre plats at University Farm, and also on the half-acre plats beside them, that Minnesota fields may be made to double and treble the net profits per acre now secured.

A careful examination of notes under figure 7 will show that these various rotations were carried out in a manner entirely normal to the average farm in the State. There was no unusual means of forcing and the soil on which these crops were grown is naturally only the average of the soils of the State.

While under the plan of this experiment only one plat was for the most part devoted to each cropping scheme, and the crops in that scheme are thus not distributed through the different seasons because of lack of land, yet the average of the several profitable rotations may properly be compared with the average of the several less profitable rotations. The differences in the yields thus secured are so pronounced that it may be positively stated that under the general plan of the better rotations the net profit per acre of Minnesota farms may be greatly increased. Thus the average profit from the crops of the seven rotation schemes yielding more than $5.87, of the control rotation, and of the six schemes which yielded over $5 per acre, after paying $3.50 rent per acre, is $6.02, or 15 cents more than the net profit of the standard rotation.

At the other extreme, the five schemes of cropping which were produced at a loss, averaged, after paying $3.50 rent, $4.72 less than the cost, or $10.59 less than the control rotation.

Thus when the individuality of the plats are merged into averages, the broad comparison most emphatically demonstrates the profit of some rotations as compared with others.

There seems no reason for minimizing the full force of these figures in the business of crop production in Minnesota. In 1899 according to the Twelfth Census, Minnesota farmers produced on 18,442,585 acres of improved land, farm products worth $161,217,304, or $8.74 per acre. Prices are now higher and the acreage of improved farm lands has been materially increased. For use in illustrating this subject we may assume that Minnesota has 20,000,000 acres of improved land, yielding an average of $10 per acre or $200,000,000 worth of live stock and farm products. The Thirteenth Census will probably show this to be too low, but the round numbers will make calculations easy. It is fair to assume that the farmers of the State do not use cropping schemes which average better than those in the third and fourth groups in Table III, in which, after paying $3.50 rent, the net income on the plats at University Farm was from $1.42 to $5 per acre. The ten cropping schemes in these two groups yielded on University Farm, an average of $3.51 per acre after paying rent. On the other hand, the 14 cropping schemes in the first two groups in Table III, yielded an average of $6.02 after paying rent. Taking into account the fact in either case that the better care of the fields on University Farm was in part responsible for the yields given, it may still in all fairness be estimated that Minnesota farmers could increase their yields at least $2 an acre simply by adopting and strictly adhering to such rotation schemes as those in the first group in Table IV.

The added income from 20,000,000 acres of improved land at $2 per acre would be $40,000,000, or an average of $200 on each of 200,000 farms. If the investigations by the United States Department of Agriculture and the State experiment stations, the instruction in agricultural high schools and agricultural colleges, in consolidated rural schools, district rural schools and farmers' institutes, supplemented by publications, both public and private, and by other means promoting good farm management, would induce the farmers to reorganize their farms properly and would result in this increased income at a cost in the State of national and State expenditures of a million dollars annually, the surplus would be $39,000,000. If $9,000,000 of this were required to rearrange the fields, move and build fences, do the field work in a better way than is now done, and buy and care for better seed, the net surplus to the people would still be $30,000,000 and, in the large view, the figures would reach this sum, leaving a net profit of $150 per farm. Speaking broadly and with averages, out of the $150 increased earnings each farmer should be able to use $50 in increasing the value of buildings, implements, machinery, and live stock, which averaged in 1900 for the State about $1,500 per farm, raising the average in 10 years to $2,000 per farm. The other $100 is needed by the average farm family to provide leisure and facilities for better education and to develop country life more rapidly.

An average of $100 more annually, devoted to better food, better schools, better home education and the social development of Minnesota's farm boys and girls would so react as to increase even more largely the income and splendid country life springing from Minnesota's land. Still another $150 per farm could be added to the incomes by developing better varieties of crops and better breeds of live stock; and it may be that still another $150 could be added by the use of fertilizers costing less than half that amount.

Several of these rotation schemes are worthy of special mention. The 5-year control rotation on the 12 check plats, 1, 6, and 11 of each of the series I, II, III, and IV, with which the other rotations were compared is of peculiar interest. This rotation is: First year (8 tons manure per acre), corn; second year, wheat; third year, timothy and clover meadow; fourth year, timothy and clover pasture; fifth year, oats. The average cash income per acre per year for this rotation for the 10 years 1900 to 1909 on these 12 plats was $15.89. The average cost per acre to produce the crops, including a rental charge of $3.50 per acre, cost of labor, machinery, and all other expenses was $10.02, leaving an average net profit of $5.87 per acre.

Wheat continuously, plat 2, series III, yielded a gross product worth $13.08 at a cost of $9.94, leaving an average net profit of $3.14, or $2.73 less than was produced by the control rotation.

Wheat continuously with 6 pounds red clover seeded with the wheat, plat 3, series III, and the crop of clover plowed under in the fall with the wheat stubble, for the same years yielded crops worth $14.88 at a cost per acre, including cost of the clover seed, of $10.90, leaving a net profit of $3.98 or $0.84 more than the plat growing wheat continuously without clover, or $1.89 less than the 5-year control rotation.

It is worthy of note that the plats which grew wheat continuously finally became infested with wild oats, probably from the droppings of horses working on them, while in the plats in the standard rotation, and in the other rotations in which cultivated crops, grain crops, and grass crops alternated, the wild oats did not even get a foothold.

CORN GROWN CONTINUOUSLY.

The very poor results on plat 7, series II, Table III, planted to corn continuously, may be a surprise to many. It is generally believed that corn has no harmful effect upon the soil. It is well known that usually after a crop of corn a larger yield of grain is secured. It will be observed that this plat gives poorer returns than plat 2, series III, on which wheat has grown continuously. This is contrary to what is generally expected since wheat has the reputation of being hard on the soil while corn is believed to be beneficial. The decreased yield may of course be partly due to increase of such insect enemies as root worms and the corn root-aphis which would have good opportunity to multiply under these conditions.

The frequent cultivation given the corn maintains during a large portion of the year an effective surface mulch which does very much in allowing the water from rainfall to percolate into the soil and in conserving it by checking evaporation. The cultivation, by aerating the soil and conserving the moisture, stimulates decomposition, thus effectively maintaining the conditions favorable for bacterial and chemical activity.

The larger yields of grain usually obtained following a crop of corn show that this crop improves the soil for other crops; but when the stalks are removed the stubble and corn roots return but very little vegetable matter to the soil, and when corn is grown year after year on the same field the vegetable matter in the soil is rapidly decomposed and depleted, doubtless more rapidly than is the case with continuous wheat growing, mainly because the cultivation of the corn stimulates the decomposition, while in the wheat field the decomposition is less rapid.

Though corn grown continuously on this plat made the soil unproductive for corn yet a study of the yields of other crops following corn in rotation on other plats show it to be a valuable crop in a rotation system where the vegetable matter is kept up by manure and by grass crops. The growing of corn, as with grass, is also conducive to the keeping of live stock, which results in more manure to add to the fields. There are few of the common field crops which can be more profitably grown on a portion of the average Minnesota farm than corn, when manure or grass crops, or both, are used to keep up the supply of vegetable matter.

MODEL ROTATION.

In 1898 the field containing the 44 rotation plats just discussed was extended to the west 20 rods and 12 more plats, 3 plats in each series, were added. Figure 8 gives the key map showing the rotations of crops of these plats.

As shown in figure 8, the five half-acre plats, A, E, B, F, and G, connected with arrows, were planted to the same standard rotation used on the check plats in the 44 plats on the east end of this same field, viz, first year, corn; second year, wheat; third year, meadow; fourth year, pasture; fifth year, oats. On the three plats

H, D, and C, connected with arrows, was planted the following rotation: First year, corn; second year, wheat; third year, clover. On the two plats I and K, connected with arrows, wheat and annual pasture were grown in a two-year rotation and on the other two plats, L and M, wheat and mangels were grown in a two-year rotation. In Tables VI and VII are presented the yields, cash value, and annual cost, also the net profit for the 10-year period, 1901 to 1910, on the respective plats in each of these two rotations.

By providing as many plats as there are years in the rotation each crop is grown each year, thus largely eliminating seasonal differences and making one rotation more nearly comparable with another. Besides, the individualities of the plats are merged into averages. The average cash value of the crops grown on the five-year rotation is $16.71; the average value of the three-year rotation is $14.49. It is worthy of note that the yield of the five-year rotation on the five plats is nearly the same as the average of this same rotation grown on the twelve check plats on the east part of this same field.

TABLE VI.—*Yields and cash value of crops grown on each of the five 5-year rotation plats.*

SERIES I, PLAT 13 (A).

Year.	Crop.	Yield.	Cash value.	Cost.
1901	Pasture ... days	57.30	$2.05	$4.47
1902	Oats ... bushels	85.00	23.21	11.71
1903	Corn ... do	85.30	29.51	15.96
1904	Wheat [1] ... do	32.00	22.53	9.59
1905	Meadow ... tons	5.83	31.72	7.18
1906	Pasture ... days	132.00	4.75	4.47
1907	Oats [2] ... bushels	44.60	12.18	10.94
1908	Corn ... do	53.60	18.55	18.08
1909	Wheat ... do	35.50	25.01	9.67
1910	Meadow ... tons	1.06	5.77	7.18
	Total		175.28	99.25
	Plus manure for corn, 1903 and 1908			5.70
	Average, 10 years (net profit $7.03)		17.53	10.50

SERIES I, PLAT 14 (B).

1901	Oats ... bushels	62.50	$17.06	$11.28
1902	Corn ... do	78.60	27.20	15.35
1903	Wheat ... do	30.80	21.68	9.56
1904	Meadow ... tons	5.77	31.39	7.18
1905	Pasture ... days	217.60	7.78	4.47
1906	Oats ... bushels	72.00	19.66	11.46
1907	Corn ... do	52.20	18.06	12.95
1908	Wheat ... do	25.00	17.60	9.43
1909	Meadow ... tons	.80	4.35	7.18
1910	Pasture			
	Total		164.78	88.86
	Plus manure for corn, 1902 and 1907			5.70
	Average, 9 years (net profit $7.80)		18.31	10.51

[1] Sown on disked corn land.

[2] Breaking $1.67; disking $0.60.

TABLE VI.—*Yields and cash value of crops grown on each of the five 5-year rotation plats*—Continued.

SERIES II, PLAT 13 (D).

Year.	Crop.	Yield.	Cash value.	Cost.
1901	Corn ... bushels	42.80	$14.81	$12.10
1902	Wheat ... do	25.10	17.67	9.43
1903	Meadow		29.92	7.18
1904	Pasture ... days	154.50	5.52	4.47
1905	Oats ... bushels	84.25	23.00	11.69
1906	Corn ... do	60.50	20.93	13.71
1907	Wheat ... do	23.90	16.83	9.40
1908	Meadow ... tons	5.01	27.25	7.18
1909	Pasture			
1910	Oats ... bushels	45.00	12.29	10.95
	Total		168.22	86.11
	Plus manure for corn, 1901 and 1906			5.70
	Average, 9 years (net profit $8.49)		18.69	10.20

SERIES II, PLAT 14 (C).

Year.	Crop.	Yield.	Cash value.	Cost.
1901	Wheat ... bushels	15.20	$10.70	$9.20
1902	Barley [1] ... do	28.50	11.03	9.54
1903	Meadow			
1904	Oats ... bushels	58.70	16.03	11.21
1905	Corn ... do	64.40	22.28	14.06
1906	Wheat ... do	22.60	15.91	9.37
1907	Meadow ... tons	1.14	6.20	7.18
1908	Pasture			
1909	Oats ... bushels	75.80	20.69	11.53
1910	Corn ... do	36.94	12.78	11.56
	Total		115.62	83.65
	Plus manure for corn, 1905 and 1910			5.70
	Average, 8 years (net profit $3.28)		14.45	11.17

SERIES III, PLAT 14 (E).

Year.	Crop.	Yield.	Cash value.	Cost.
1901	Meadow ... tons	2.30	$12.51	$7.18
1902	Pasture ... do	1.95	10.61	4.47
1903	Oats ... bushels	61.70	16.84	11.26
1904	Corn ... do	37.10	12.84	11.58
1905	Wheat ... do	30.90	21.75	9.57
1906	Meadow ... tons	2.18	11.86	7.18
1907	Pasture ... days	96.00	3.50	4.47
1908	Oats ... bushels	42.20	11.52	10.89
1909	Corn ... do	74.72	25.85	15.00
1910	Wheat ... do	25.36	17.85	9.44
	Total		145.13	91.04
	Plus manure for corn, 1904 and 1909			5.70
	Average, 10 years (net profit $4.84)		14.51	9.67

[1] Substituted for grass which did not catch.

TABLE VII.—*Yields and cash values of crops grown on the three-year rotation for ten years, 1901–1910.*

SERIES III, PLAT 13.

Year.	Crop.	Yield.	Cash value.	Cost.
1901	Clover [1] ... tons	1.58	$8.60	$8.08
1902	Corn ... bushels	62.50	21.63	13.89
1903	Wheat [2] ... do	24.40	17.18	9.42
1904	Clover ... tons	4.26	23.17	8.08
1905	Corn ... bushels	64.10	22.18	14.04
1906	Wheat ... do	13.30	9.36	9.16
1907	Clover ... tons	1.25	6.80	8.08
1908	Corn ... bushels	38.60	13.36	11.71
1909	Wheat ... do	20.33	14.31	9.32
1910	Clover ... tons	0.62	3.37	8.08
	Total		139.96	99.86
	Average, 10 years (net profit $4.01)		14.00	9.99

[1] Eight pounds seed at 15 cents.

[2] Land disked, not plowed.

TABLE VII.—*Yields and cash values of crops grown on the three-year rotation for ten years, 1901–1910*—Continued.

SERIES IV, PLAT 13.

Year.	Crop.	Yield.	Cash value.	Cost.
1901	Wheat .... bushels..	13.60	$9.57	$9.17
1902	Soy beans	....	....	....
1903	Corn .... bushels..	54.70	18.93	13.18
1904	Wheat .... do....	27.30	19.22	9.48
1905	Clover .... tons..	4.86	26.44	8.08
1906	Corn .... bushels..	36.10	12.49	11.49
1907	Wheat .... do....	19.10	13.45	9.29
1908	Clover .... tons..	3.24	17.63	8.08
1909	Corn .... bushels..	39.17	13.55	11.77
1910	Wheat .... do....	20.93	14.73	9.34
	Total	....	146.01	89.88
	Average, 9 years (net profit $6.23)	....	16.22	9.99

SERIES IV, PLAT 14.

Year.	Crop.	Yield.	Cash value.	Cost.
1901	Wheat .... bushels..	13.80	$9.33	$9.17
1902	Wheat .... do....	18.10	12.74	9.27
1903	Clover .... tons..	3.85	20.94	8.08
1904	Corn .... bushels..	45.10	15.60	12.31
1905	Wheat .... do....	20.60	14.50	9.33
1906	Clover .... tons..	1.91	10.39	8.08
1907	Corn .... bushels..	40.80	14.12	11.91
1908	Wheat .... do....	22.76	16.02	9.38
1909	Clover .... tons..	1.40	7.62	8.08
1910	Corn .... bushels..	33.05	11.44	11.21
	Total	....	132.70	96.82
	Average, 10 years (net profit $3.59)	....	13.27	9.68

In Table VIII the average cost of production of the five crops in the standard rotation is compared with the production of wheat grown continuously.

TABLE VIII.—*Cost of cropping under standard rotation and continuous wheat cropping.*

	Cost per acre.
Cropping under 5-year rotation system:	
Manuring, 8 tons per acre once in 5 years	$2.50
Corn, once in 5 years	7.51
Wheat, once in 5 years[1]	4.39
Meadow, once in 5 years	3.88
Pasture, once in 5 years	1.40
Oats, once in 5 years	5.83
Total cost, except rent, per acre for 5 years	25.51
Rent	3.50
Average annual cost per acre	5.10
Total cost per acre	8.60
Cropping to wheat continuously:	
Average annual cost, except rent, per acre	5.12
Rent	3.50
Total cost per acre	8.62

NOTE.—The above figures showing the cost of the two systems of cropping were taken from the United States Department of Agriculture, Bureau of Statistics Bulletin No. 73, and Minnesota Agricultural Experiment Station Bulletin No. 117 on the cost of producing farm products. The figures showing the average for the State were used. To get the cost of meadows and pastures it was necessary to establish a price for grass seed. The only figures available were those given in the United States Department of Agriculture Yearbook, showing the wholesale prices in Chicago. These prices were for the 10 years 1897–1906, inclusive, 3.17 cents per pound for timothy and 7.7 cents per pound for red clover. As prices for grass seed are at present high, an arbitrary price of 12 cents for clover and 3½ cents for timothy was used. The seeding used on those plats was 6 pounds of clover and 8 pounds of timothy per acre, worth at 12 cents and 3½ cents, respectively, $1. This cost of grass seed is charged equally against the meadow and pasture. The only cost against the pasture is 50 cents for seed and 90 cents for fencing.

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[1] Seventy-three cents is deducted from cost of growing wheat on fall plowing, as wheat in this rotation is grown on disked corn land.

Since the average value of the crop from this 5-year rotation, as shown in Table III, is $2.73 more than the value of the wheat crop, we have here another proof that the figures given above are correct, showing that an efficient system of crop rotation would increase the income of land which grows wheat continuously by at least $2 per acre.

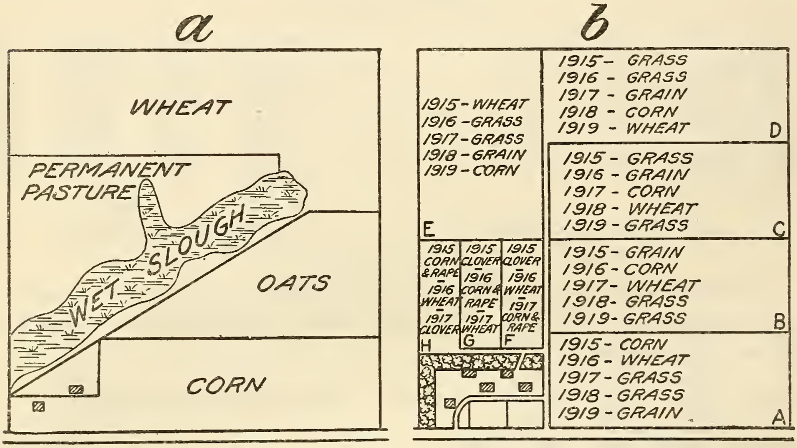

FIG. 9.—*a*, 160-acre Dakota County farm as cropped in 1906. The whole farm is tillable, but is poorly organized. The average distance from the farmstead to the fields is 70 rods, and the total amount of inside fencing required to fence all of the fields is 892 rods. *b*, Same farm as in *a*, but reorganized for a 5-year rotation. The average distance from the farmstead to the fields is now but 24 rods, and the total amount of fencing required for inside fences is only 640 rods. The crops are each year to be changed by rotation so that each field will produce each crop once in five years.

THE 5-YEAR ROTATION APPLIED TO FARM CONDITIONS.

The maps in figure 9 illustrate how this 5-year rotation actually applies to a 160-acre farm. The farm chosen is a 160-acre farm in Dakota County, Minn., all of which is tillable. The original arrangement of fields and crops in 1906 is shown in *a* and the reorganization plan in *b*.

The maps in figure 10 show the original (*a*) and the revised plan (*b*) of another farm. Here *b* provides for five 30-acre fields for the rotation. The crops for but one year are shown, but the crops are to be changed each year on each field the same as has been carried out on the rotation plats. Corn is followed by grain and grass seed, grain by meadow, meadow by pasture, and pasture by oats; then again, starting with corn, the rotation cycle of five years is repeated indefinitely.

The foregoing maps show very plainly how a farm that is all tillable may be conveniently divided and cropped. It will be observed by comparing the two plans that there are fewer fields and they are of better form to work, as the farm is reorganized, than under the former plan. Very little more fencing is used to bring all the fields under fence in the rotation plan than for permanent pasture under the former plan. This cost will be offset many times by the increased yields of pasturage from land that has been in hay but one year over old pastures, under the conditions in Minnesota, by the increased yields of grain or corn on the pasture sod over yields obtained on old grain fields, and by the pasture secured in the stubble fields in which rape, turnips, and other catch crops are grown.

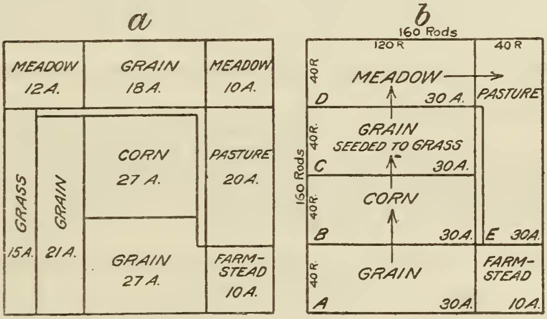

FIG. 10.—*a*, Another unorganized farm; *b*, same farm reorganized.

YIELDS OF CORN, WHEAT, AND HAY UNDER DIFFERENT SYSTEMS OF CROPPING.

Table IX shows that corn, wheat, and hay yielded most when these three classes of crops were in rotation, and that corn and wheat yielded least when grown continuously. On none of the plats where hay was grown continuously was there a yield large enough to pay as compared with hay grown in rotation.

TABLE IX.—*Comparative yields of corn, wheat, and hay under different systems of cropping, 1899–1907.*

Year.	Corn.			Wheat.			Hay.	
	Corn continuously.	Corn in 3-year rotation.	Corn in 5-year rotation.	Wheat continuously.	Wheat in 3-year rotation.	Wheat in 5-year rotation.	Hay in 3-year rotation.	Hay in 5-year rotation.
	Bushels.	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*	*Tons.*	*Tons.*
1899	20.8	51.1	31.3	22.5	25.3	27.3	....	....
1900	37.5	42.6	58.0	14.5	27.3	25.6	....	....
1901	13.9	42.0	42.8	16.0	13.5	15.2	1.58	2.36
1902	(1)	62.0	78.6	17.0	18.1	25.1	2.25	1.95
1903	23.6	54.7	85.3	16.3	24.4	30.8	3.86	6.10
1904	11.1	45.1	37.1	20.8	27.3	32.0	4.26	5.77
1905	25.1	64.1	64.4	20.8	20.6	30.9	4.86	5.81
1906	27.6	36.1	60.5	14.1	13.3	22.6	1.91	3.18
1907	23.6	35.2	52.2	24.5	19.1	23.9	1.25	1.42
Average, 9 years	[2] 22.9	48.1	56.7	18.5	21.0	25.9	[3] 2.85	[3] 3.80
Gain	....	25.2	33.8	....	2.4	7.4	....	.95

[1] Record lost. [2] Eight years. [3] Seven years.

NOTE.—The plats continuously planted to one crop and the 3-year rotation plats were not manured. The 5-year rotation plats received 8 tons of manure every fifth year.

PROFITS INCREASE MORE RAPIDLY THAN YIELDS.

Table X shows the relative profits in Minnesota from larger yields of wheat or other crops as compared with smaller yields. Ten bushels of wheat have been necessary to pay the average cost, including a land rental of $3.50 per acre.

TABLE X.—*Showing net profit or loss from varying yields of wheat in Minnesota, years 1902–1907, inclusive.*

Yield.	Average farm price in Minnesota, 6 years. [1]	Value per acre.	Cost of production per acre. [2]	Net profit or loss. [3]
20 bushels	$0.742	$14.84	$7.61	$7.23
18 bushels	.742	13.36	7.55	5.81
16 bushels	.742	11.87	7.49	4.38
14 bushels	.742	10.39	7.43	2.96
12 bushels	.742	8.90	7.37	1.53
10 bushels	.742	7.42	7.31	.11
8 bushels	.742	5.94	7.25	−1.31

[1] U. S. Dept. Agr., Yearbook 1907, p. 623.
[2] Minnesota Agrl. Expt. Sta. Bul. No. 117, p. 23.
[3] Minus sign shows a loss.

SUMMARY OF ROTATION EXPERIMENTS.

(1) Cultivated crops, as corn, potatoes, and mangels, grown continuously, rapidly decrease the productivity of soils. This is largely due to the fact that cultivation stimulates decomposition of vegetable matter, leaving too small a supply of fresh vegetable matter in the soil.

(2) Grain crops grown continuously decrease the productivity of soils. This, it is believed, is in part due to reducing the fresh vege-

table matter which supports chemical and wholesome bacterial activity in the soil and in part due to an increase in weeds.

(3) A rotation of corn, oats, millet, and barley, which tend to exhaust the supply of vegetable matter, did not produce better results than continuous wheat cropping.

(4) A 2-year rotation of mangels and wheat, both of which reduce vegetable matter, gave little better yields of wheat than wheat continuously.

(5) A 2-year rotation of wheat and annual pasture gave greatly increased yields of wheat, presumably in large part because the annual pasture crop added fresh vegetable matter to the soil, greatly increasing the bacterial and chemical activities of the soil and improving its physical condition.

(6) A 3-year rotation of corn, wheat, and clover with no manure did not give as large yields of corn and wheat as were obtained from a 5-year ''standard'' rotation of corn, wheat, meadow, pasture, and oats, with some manure applied to the corn. The lower yield on the 3-year rotation is presumably due mainly to the fact that clover once in three years did not maintain the supply of fresh vegetable matter so fully as did the 5-year rotation with two grass crops and 8 tons of manure once every five years.

(7) Among the advantages of vegetable matter in the soil the following may be named: It aids aeration, retains moisture, deepens the soil, prevents baking, checks leaching and washing, stimulates decomposition, supplies easily usable plant food, affords favorable conditions for bacteria, increases chemical activities, and presumably aids in disposing of or neutralizing substances left by crops which are evidently toxic to the same or to other crops.

(8) The combination of cultivated crops, grain crops, and grass crops, including clover, as in the 5-year standard rotation, not varying greatly from two-fifths of the time in grass, results in substantial profits.

(9) In a word, the best rotation schemes yield $12 to $16 worth of crops, at a cost, including $3.50 rental, labor, and all other expenses, of $7 to $11. With a net profit of $3 to $6 per acre, and under the conditions of the average farm there should be secured a net profit of $2 to $4 per acre on all the cultivated acreage.

IMPORTANCE OF GRASS CROPS.

Under the present farm and economic conditions in the middle Northwest many farms have too large a percentage of land planted to grains. This is shown by the facts given in Table III and also by the fact that farmers may keep one-third to one-half of their land in grass and other forage crops and in the end make more money per acre and build up better farms. Continuous cropping of grain, including the rotation of the small grains with corn, results in reducing the amount of vegetable matter in the soil and, unless the corn is in large proportion, in increasing the weeds and in otherwise reducing the productivity of the soil until the yields are no longer large enough to be profitable. On such farms, owing to the beneficial effect the grass and clover have in building up and cleaning the soil, it undoubtedly pays to increase quite largely the proportion of the farm kept in grass.

There are few cases in which hay or other roughage can not be put to some profitable use on the farm, either by increasing the amount of live stock kept on the farm or at least by buying stock, cattle, or sheep to feed during the autumn and winter. In some cases hay and other roughage may be sold at a profit, even if it does remove vegetable matter and plant food from the farm. Dairy farming is especially favorable to keeping the soil well supplied with fermentable vegetable matter, and therefore to the production of profitable yields of all crops. Besides, with due care in saving the manure, little of the nitrogenous and mineral fertilizing ingredients of the soil is wasted or removed from the farm.

Since the net profit on an acre of wheat, oats, or other small grain on run-down soil is very small, decreasing the crop of wheat and using the land for grass, even though the grass can not be used to great advantage, will under such conditions not materially decrease the net profit of the farm. Table X shows that the margin of profit in raising wheat is not reached on lands on which the interest or the rental charge amounts to $3.50 per acre unless the crop produces 10 bushels or more per acre and that profits rise rapidly with every bushel above that amount.

The cost of producing hay and pasture in Minnesota and surrounding States is less than that of producing any of the other common field crops, as no extra preparation of the land or sowing is necessary, the grass seed usually being sown with the preceding grain crop. All the charges to be made against the grass crop are rent, cost of seed, and harvesting, and sometimes fencing, and the crop in order to return equivalent net profits does not need to yield a product with as large a gross value as corn or the small grains.

Where live stock is kept and the grass is marketed as beef, pork, mutton, or milk, the value of the grass or other raw product is often so increased as to make a larger net return per acre than had grain crops been grown. In addition to whatever profits may be made by feeding the grass crops to live stock over selling it as hay, the grain or cultivated crop following the grass is usually stimulated to yield enough more than it would following a grain crop to be equivalent to that which would have been secured from two years of grain giving low yields. As a rule 75 acres of grain each year on land that grows a crop of clover every fourth year will yield a larger net profit than will 100 acres sown to grain continuously.

THE USE OF STATISTICS OF COST OF FARM PRODUCTS.

In studying the question of farm management it early became evident that actual cost data would be necessary in determining the profits of any scheme of farm production. To collect this cost data the Bureau of Statistics of the United States Department of Agriculture, in 1902, joined in cooperation with the division of agriculture of the Minnesota Agricultural Experiment Station to secure from Minnesota farmers the facts relative to the cost of producing field and live-stock products.

The work was carried on under the supervision of the station officials, the Department and the station each bearing approximately one-half the expense. The results already obtained from this line of farm-management research, as published in various bulletins, have received the highest commendation and are being used both in economic discussions regarding the cost of production and in the organization of farms.

A plan was devised to secure the facts at first-hand from general farmers. Three so-called statistical routes were established in representative farm districts of the State, namely, at Northfield, in southeastern Minnesota, at Marshall, in southwestern Minnesota, and at Halstad, in northwestern Minnesota. A student of the College of Agriculture was appointed route statistician and placed in charge of each route. These statistical routes have been continuously maintained up to the present time. The results of the first three years (1902, 1903, and 1904) are published in U. S. Department of Agriculture, Bureau of Statistics Bulletin No. 48 and Minnesota Agricultural Experiment Station Bulletin No. 97. The average results for six years, 1902 to 1907, inclusive, are published in Bureau of Statistics Bulletin No. 73 and in Minnesota Agricultural Experiment Station Bulletin No. 117. The cost of producing dairy products, 1904 to 1909, is published in Bureau of Statistics Bulletin No. 88 and in Minnesota Agricultural Experiment Station Bulletin No. 124.

The Department of Agriculture and the experiment station inaugurated these cooperative investigations with a view to extending them to other States if the plan proved efficient and economical and the results warranted the expenditure. Subsequently, the Office of Farm Management in the Department of Agriculture developed a somewhat different system of securing cost of producing farm products.

Under the route statistical plan the figures for each route are based on data gathered by the route statistician from eight farms, chosen because they are typical of the general region in which the route is located. The route statistician goes daily to each farm, securing a detailed statement of man and horse labor expended upon various enterprises for the previous day, cash expenditures and receipts, feeds fed to all classes of live stock, amounts of farm products used in the household, and other items, as yields of crops. Summaries of these results are sent monthly to the central office, where they are recorded in the set of double-entry books which is kept for each farm on the route, and at the end of the year a business statement for each farm, showing gains or losses on each enterprise and on the farm as a whole, is prepared at the central office and sent to the owner of the farm.

Under the individual farm plan of the Office of Farm Management, on the other hand, the farmer himself keeps a daily record of time of men and horses spent on each enterprise, a record of yields, cash expenditures, and other items, and reports periodically to the central office on forms supplied to him.

These two methods are being compared, and it is evident that, besides being checks upon each other, the first plan is better adapted to some conditions and the second better to other conditions, and that a combination of the two plans will best secure the desired results. By combining the two methods of investigation plans have been developed under which general data of the cost of farm products should be secured in each and every State at the earliest practicable date.

To use these data of the cost of producing live stock and other products the farmer needs to organize his farm somewhat systematically and to have a knowledge of simplified forms of recording the results of his farm products in terms of money. He should correct these published figures of the cost of production so as to make them applicable to his conditions and to apply them to the values of his products in such a manner as to enable him to determine net profits. He will then be able to compare the net profits of each kind of crop, of each system of rotation, and of each general method of farm management on his own farm, on the farms in the vicinity, and on farms in other localities.

The following tables, based on Bureau of Statistics Bulletin No. 73, give some of the valuable facts secured by these investigations:

TABLE XI.—*Average annual cost per acre of producing field crops, 1902–1907, including rental of land.*

(See U. S. Dept. Agr. Bureau of Statistics Bul. 73 and Minnesota Agrl. Expt. Sta. Bul. 117 for detailed tables.)

Crop.	Number of table which shows detailed cost.	Northfield (Rice County).	Marshall (Lyon County).	Halstad (Norman County).	Minnesota Agrl Expt. Sta.
Barley, fall plowed	XIV	$9.647	$8.880	$7.003	....
Clover, cut for seed	XV	6.500	....	....	....
Corn, ears husked from standing stalks	XVI	11.658	9.662	....	....
Corn, cut, shocked, and shredded	XVII	15.297	....	....	....
Corn, cut, shocked, and hauled in from the field	XVIII	....	10.265	....	....
Corn, grown thickly and siloed	XIX, XX	20.627	....	....	$19.187
Flaxseed, thrashed from windrow	XXII	10.072	....	7.272	....
Flaxseed, stacked from windrow	XXIII	....	8.861	7.028	....
Flaxseed, bound, shocked, stacked, and thrashed	XXIV	....	8.400	6.895	....
Fodder corn, cut and shocked in field	XXV	10.733	....	8.912	....
Fodder corn, cut, shocked, and stacked	XXVI	12.362	....	....	....
Hay, timothy and clover (first crop)	XXVII	6.185	5.553	4.567	....
Hay, timothy and clover (two cuttings)	XXVII	7.178	....	....	....
Hay, millet	XXVIII	9.317	7.971	6.349	....
Hay, wild grasses	XXIX	6.036	5.478	2.970	....
Hay, timothy	XXX	....	....	....	....
Hemp	XXXI	6.741	....	....	....
Mangels	XXXII	....	....	....	32.682
Oats, fall plowed	XXXIII	9.854	9.039	7.110	....
Oats, on disked corn stubble	XXXIV	9.158	8.092	....	....
Potatoes, machine production	XXXV	....	....	....	....
Potatoes, machine production (use of fertilizer)	XXXVI	....	....	....	....
Timothy, cut for seed	XXXVII	5.985	5.512	4.310	....
Wheat, fall plowed	XXXVIII	9.861	8.389	6.977	....

TABLE XII.—*Cost of labor operations per acre at various points in Minnesota.*[1]

Crop.	Northfield (cost per acre).	Marshall (cost per acre).	Halstad (cost per acre).
Grain:			
Plowing—			
Fall	$1.256	$1.141	$1.130
Spring	1.311	1.171	1.186
Cleaning	.023	.035	.030
Dragging	.239	.172	.281
Seeding	.371	.236	.272
Cutting	.460	.333	.333
Shocking	.218	.110	.135
Stacking	.789	.539	.481
Thrashing	.528	.257	.312
Hay:			
Mowing	.368	.328	.363
Raking	.178	.213	.248
Hauling in	1.099	1.242	1.273
Corn:			
Shelling seed	.026	.025	....
Plowing	1.311	1.171	....
Dragging	.544	.439	....
Planting	.240	.255	....
Cultivating	1.806	1.453	....
Husking	3.456	2.473	....

[1] From U. S. Dept. Agr. Bureau of Statistics Bul. 73 and Minnesota Agrl. Expt. Sta. Bul. 117.

NOTE.—Table XII comprises only those items which are composed of labor alone.

METHODS OF USING FARM-MANAGEMENT DATA.

In subsequent pages of this bulletin an attempt is made to give some of the formal methods needed by the farmer in utilizing the results of such experiments as the rotation experiments previously mentioned, the results of the investigations to secure data as to the cost of farm products, and data secured as to yields and values in his own fields and barns; that in a simplified way he may be able to compare the relative profits of his crops, his rotation schemes, his methods of live-stock production, and his general methods of farm management, both within his own farm and with other farms.

The effort is also made to offer a pedagogical plan under which the teacher in the college of agriculture, in the agricultural high school, and especially in the consolidated rural school, or even in the one-room school, wherever farm pupils are taught, may be able both to teach the general principles of farm management, and to give the pupils skill in making comparisons and efficiency studies in relation to farm methods and practices.

It is not too much to hope that attempts at placing farm organization and farm management on an engineering basis will result in a research and educational movement which will help to give to all farm youth training in the elements of scientific farm organization; will help to produce efficiency farm engineers, as there now are efficiency engineers in manufacturing enterprises; and will help eventually to transform the generally poorly organized farm business into a business with scientific plans and highly efficient management; and will yet retain the family-size farm where folks are the greatest product.

FARM-MANAGEMENT INVESTIGATIONS NEEDED.

The cultivated area of the farms of the United States is approximately 500,000,000 acres; and the value of the crops from this cultivated area is about $5,000,000,000. Work already done by the State experiment stations and the General Government has shown that by better methods of crop rotation alone this product can be increased easily 10 per cent, or $500,000,000, or $1 per acre. The States and General Government having assumed the task of carrying forward agricultural research and agricultural education, have thus brought themselves face to face with the problem of leading the farmers into this increased production. Extension of the methods which have shown the possibilities of improved methods of farm organization promise to carry this work forward on all the farms of the country, thus bringing up the average of the whole. The leading plans, mentioned below, are proving adapted to the work of investigation and education so as to reach all districts of each and every State.

CROP-ROTATION EXPERIMENTS NEEDED.

There is needed in each State, valley, or even county or lesser district with distinctive agricultural conditions, experiments on series of uniform plats, to compare 10, 20, 30, or more of the seemingly most practical rotation schemes. Some of these should be especially devoted to determining which rotation schemes pay best without fertilizers, and in others commercial fertilizers should be supplied to one or more of the crops. In Minnesota the experiments reported in this bulletin show broadly some of the unsuccessful cropping schemes and others which are successful, thus helping to narrow down the further trials to the more practicable plans. Sufficient land should be available so that each rotation scheme would have a plat for each year in the rotation, and the more important rotations should be on duplicate series of plats. Several hundred one-tenth acre plats at the State experiment station and at each of nine branch stations would fairly compass the needs for the more scientific part of the field work in a large State like Minnesota or Iowa. In a State broken up with many valleys, more branch stations are needed. The land for these plats should be most carefully chosen by careful inspections aided by means of soil borings, discarding all portions of the fields not reasonably uniform. The plans should be carefully made and passed upon by a large committee of the best experts in farm management, plat testing, and soils in the State stations and in the United States Department of Agriculture. Men should be employed to do the work who make this their first duty, and the greatest care should be taken to have all controllable factors under control. Constant physical, chemical, and biological surveys and tests of the soil should be made, and samples of the soil and of the crop should be regularly kept.

The possibilities and importance of the lessons to be deduced from the data after 10 or 15 years are foreshadowed in the results shown in Tables I to IV. Data thus secured in a broad way would help make the teaching of crop rotation as practical as the teaching of bridge building.

COST OF FARM PRODUCTS.

The results given in Table XI, p. 41, of the cost of producing farm products and their use in various ways throughout this bulletin demonstrate the fact that such data are enormously useful, both to the farmer and in the school. And that they can be secured in general agricultural areas and in limited areas of special conditions or special farming has been amply proven. That these data can be applied to the results of rotation experiments, as well as to the results on farms organized for crop rotations, is amply demonstrated throughout this bulletin.

THE VALUE OF FARM PRODUCTS.

Tests were applied to determine the accuracy of the average prices at the farm of the various farm products as published by the Bureau of Statistics of the United States Department of Agriculture, and these data were found reasonably accurate and more reliable than any other available data.

FACTS FROM SUCCESSFUL FARMERS.

The facts being gathered by such organizations as the Office of Farm Management of the United States Department of Agriculture and State experiment stations, and similar data gathered by farm demonstration men and others whose research or instructional work brings them in contact with the business of bright farmers, are gradually being accumulated into a body of usable knowledge. This knowledge is vastly more extended than that which is secured by formal rotation experiments, but it greatly needs the more carefully wrought-out work of the rotation plat tests, controlled by the results of the laboratory and the cost tables, to correct it and reduce it to a more scientific basis. Eventually the experimenters, the farm management experts, the farm demonstrators, the teachers in consolidated rural schools, and in higher country-life schools, and the writers of textbooks will put all these data to the test of comparative research. They will finally be compared in the terms of the farmer's own results. When the supreme test of profit with improved soil productivity is applied, farmers will settle down to using those plans which give a large product per acre and per farm worker.

THE TEACHING OF FARM MANAGEMENT.

The presentation of the subject of farm management in the classroom to students who have grown up on the farm and are therefore conversant with the average farm conditions and difficulties is a most delightful experience to the teacher who is really master of the subject. In the Minnesota School of Agriculture, where the plans herein presented were devised, the students, about two-fifths of whom are girls, come from the rural schools and spend three winters of six months each in the agricultural high-school course, and nearly all return to the farm. During the first year of the course each student, after receiving brief instruction in farm planning, is required to draw a plan of his own home farm with the fields as they were farmed the previous year. The second year, in the classes in field crops and farm management, he is required to make a map of the farm as cropped during the intervening year and to accompany this with a business statement and invoice showing the kinds of live stock used, sales, and similar data. Each student is then required to project a plan for reorganizing the fields and farm scheme generally, as shown under students' plans further on in this bulletin.

The most wholesome and intense interest is thus developed in the students concerning the efficiency of the plans in vogue for their home farms and in the possibility of increasing products and profits by the reorganization of the farm. Each student is led to a keen appreciation of the advantages as well as the deficiencies of his home farm. The girls as well as the boys take a deep interest in this subject, and their work shows that they grasp the significance of the farm plan deliberately made, as compared with many of the home farm plans which, like Topsy, "just growed." And the intelligent discussion of definite plans of farms under conditions with which the students are familiar rapidly educates their judgment as to the relative values of crops, methods of crop rotation, methods of farm management, and methods of the care and marketing or use of crops and live stock. No better methods have been devised of teaching judgment in practical farm matters, so that the farmer can better learn from his own farm conditions.

That this subject is not over difficult is annually demonstrated by the fact that most students after a reasonable amount of instruction, in which numerous farms are discussed before and after reorganization, succeed in making at least fairly acceptable plans for their home farms. In some cases the student is able to be in constant consultation with his father, in which case the plan finally adopted is based on the combined judgment of the student, his father, and the teacher. In numerous cases the father has chosen to put into operation the plan thus developed, and frequently students themselves have come into the management of the farm and have adopted the plan as made at the school or as further developed as experience and knowledge of the farm conditions made advisable.

TEACHING FARM ORGANIZATION IN CONSOLIDATED RURAL SCHOOLS.

The two thousand consolidated rural schools already established and the tens of thousands for which there is room and need among the 6,000,000 farms of the United States offer the most natural place to teach the subject of farm organization. Here the school principal, if he is experienced and trained in this subject, has the most unique of pedagogical opportunities. Given typical conditions—of 150 pupils from as many farms, coming in public-school wagons to a central 5-room school, with its 5 teachers, one of whom is trained to teach agriculture and one home making, a 10-acre school farm, and laboratory facilities—there will be about 50 pupils in the seventh and eighth grades and in the first two high-school years. These 50 pupils will generally attend school 6 months and work on the home farms the alternate 6 months, giving the teacher of agriculture opportunity, while helping supervise their home work, to become acquainted with their home farms. Thus scores of farms will be the practical basis for much of the instruction in farm management. The outer half of the school farm can also be developed as a demonstration and practice laboratory, where crop rotations, methods of soil fertilization, and ways of cultivating crops can be demonstrated, and practice can be given the pupils doing many things well under the critical eye of the master.

Beginning at the fourth grade, the pupils can be required, in connection with their geography, to construct a map showing at least approximately the plan of the home farm for the previous year, as in figures 18 and 20. If the farm has been carefully laid out and measurements are known, the pupil's map can be made to scale with some accuracy. At the close of each crop year the pupil can be required to make a map of the farm, showing the cropping scheme and other features for that year. Thus at the end of the tenth grade, or middle high-school year, he will have made seven annual maps of the home farm. The general form of these annual maps can be fashioned somewhat after the plan shown in figure 22, and thus serve as a history of yields, prices, and other items, as well as of the kind of crop grown on each field.

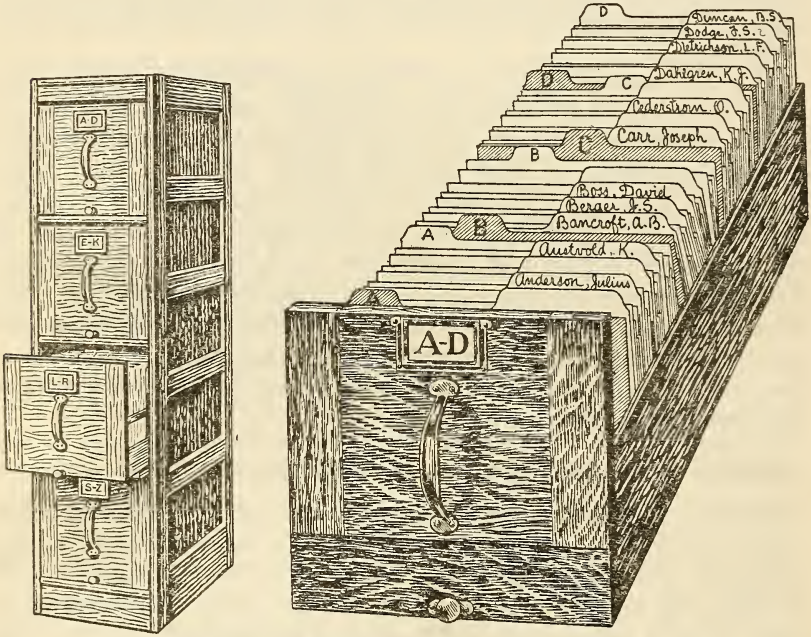

Fig. 11.—File case for farm-management students' work.

There should be in each consolidated rural school a suitable filing case such as is used for ordinary letter filing, taking sheets 8½ by 11 inches. (See fig. 11.) Each student should be allotted a place in this filing case with one or more division cards carrying his own name. In this file each student can place his annual maps and such other maps and statements of the farm business as he makes from time to time as a part of his class work.

Before the student passes out of the consolidated rural school, at the age of 16 to 18 years, he or she can be required to plan the reorganization of the home farm on a key map as shown in figure 15, and such supplementary maps as transition maps, figures 12, 13, and 14; also maps for annual records, as in figure 16, and likewise maps for records of manuring, as in figure 17, supplemented by such forms for tabular statements, summarized records, invoices, and other forms as may be made part of the school work. Table XIII is given as an example. In column 5 is shown the manner of entering the crops and acreages by fields for a given year. In Table XIV is shown a form of tabulating the gross product, the yield per acre, the price, the cost, and the profit per acre by kind of crop. On similar blanks can be tabulated for a series of years each class of facts, as yield, price, or net profit, that averages may be struck for a series of years.

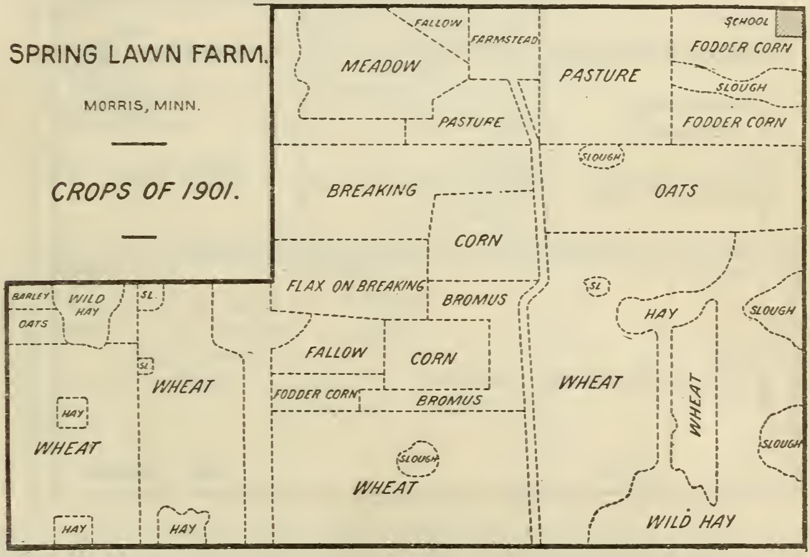

FIG. 12.—Spring Lawn Farm in 1901, with fields as handled from year to year by successive renters who had no interest in the permanent plan nor in the future productivity of the fields.

These school activities in connection with the home farm will result in the boy or girl early entering into discussions at home with the parents concerning the management of the farm, bringing home to the parents somewhat of the viewpoint of the formalities of farm organization.

When the maps have accumulated covering the entire series of years in the rotation, a summary map can be used in which can be recorded the averages representing the product of each field for the same series of years.

In Table XIV is given a blank form suggesting the manner of assembling under box heads data from a large number of fields. The student is required to prepare this tabular form and to place in it the acreages from the annual history sheets, and, as shown in Table XIII, projected from his key map. This exercise enables the student to check up his key map so that each rotation is carefully worked out in each field and it also teaches him a general plan for arranging and tabulating a form on which can be entered the yields of the respective crops on the various fields.

Each student may then be required to make a statement showing the proportion of each crop to be fed out on the farm, to be sold on the market, or to be disposed of in other ways, and to designate the kinds and numbers of animals to be fed these crops with such purchased feed and sales of crops as he may propose. He may also be required to give plans for buildings, an itemized statement of machinery and implements required to show the proportionate value of equipment and land, and other similar data. He should also be required to give two invoices, showing the form of invoice at the beginning of each of the two years and also showing the relation of this invoice to the definite system of accounts he may desire to use.

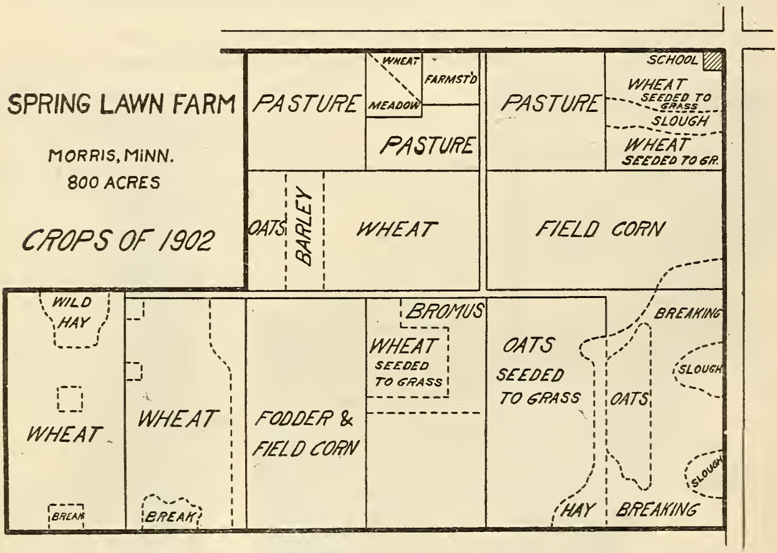

FIG. 13.—Spring Lawn Farm in 1902, the first transitory year, showing the first steps in the transition from the unsystematic farm in 1901, shown in figure 12, to the permanent arrangement of fields as outlined on the key map in figure 15. Note that the irregular pieces of wild hay land are being drained and broken and some of the old fields seeded to grass.

If a system of double-entry farm bookkeeping is taught separately from the classes in farm management, it should be in some harmony with the plan of keeping records under the key map.

While the plans made during the consolidated rural-school course will be largely products of the students, they will represent many earnest discussions in the home, among the students, between the student and his teacher, often between the teacher, the student, and the farmer, and many times between groups of farmers. Both in the school and in the home and neighborhood discussions, such figures as are given in Tables XIII and XIV, also Tables XI and XII, giving averaged relative yields, values, cost, and net profits, as published by experiment stations and departments of agriculture, will be extensively used. Averages from the farms of the district, especially once 10-year averages are available from a number of systematically arranged farms, will also become very useful parts of these discussions. And thus centered about the school will be most vital efficiency discussions concerning the methods commonly employed in the management of the farms of the district and county.

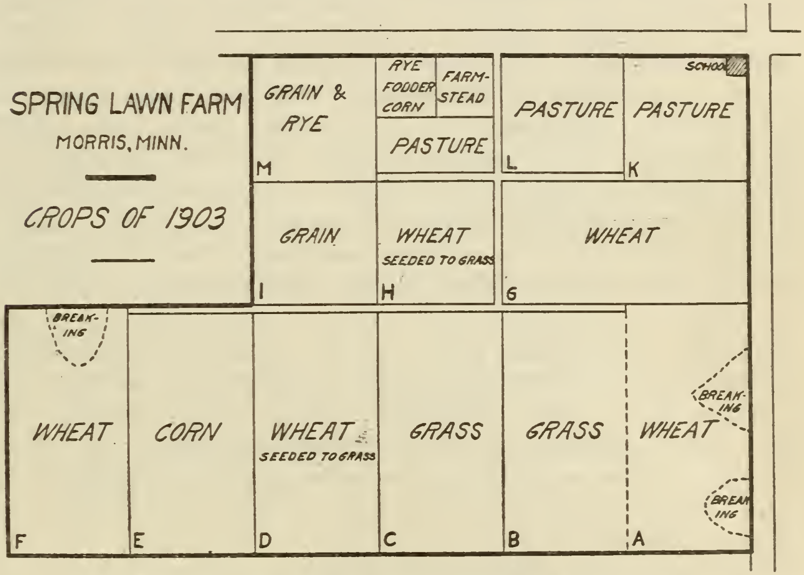

FIG. 14.—Spring Lawn Farm in 1903, showing the second transition year, where crops on a number of fields have been brought into the regular rotation. The fields have all been formed up as they are to be permanently. The last of the sloughs are drained out and broken ready for crops in 1904. Two fields, B and C, are in grass, and D is seeded. The three will furnish the pasturage and hay for the next year.

It is manifest that the character and value of these discussions and of the instruction will depend mainly on the ability, earnestness, and tact of the teacher of agriculture. It is also manifest that if a teacher can thus be the center of vital discussions annually of the methods of managing the farms, the value of his services will be cumulative, leading to longer tenure in this important office as principal of the consolidated rural school in the rising scheme of education for country life. In the most vital way this bringing of the organization and reorganization of each farm into the school work will eventually give the wide-awake teacher a general and even a detailed knowledge of most of the 100 to 200 farms of the consolidated rural district. It will give him great skill in making farm plans and in judging as to the best combination of crops in rotation, as to the best arrangement of live stock with the cropping scheme, and as to the general system of farm management which will best meet the conditions of each farm and farm family. The young man who desires to enter the profession of efficiency farm engineer can hardly find a better opportunity to learn the practical side of his business than to spend a few years after taking his college course in the principalship of a consolidated rural school in the district where he must thus make good in teaching this subject in a community of progressive farmers.

And it seems easy to forecast that, from the ranks of those who succeed as principals of consolidated rural schools, not alone in teaching farm management but in teaching many farm subjects and in dealing with the general problems of country-life education, will be chosen the men who will place on a more efficient basis the office of county superintendent, who in turn can greatly assist in bringing about uniformly efficient teaching of farm management and other agricultural subjects in the consolidated rural schools of the country.

Both the rotation key maps and the transition maps serve as excellent bases for discussions of farm-management problems with the entire class. This is especially true in the consolidated rural school where the fathers and older brothers also take a lively interest in suggestions for reorganizing the farm plan, thus bringing to the school through the pupil many questions which arise in the actual business of the farm.

THE KEY-MAP METHOD OF ORGANIZING THE FARM.

That the key-map method of organizing or reorganizing a farm aids in giving definiteness and accuracy is demonstrated by figures 12 to 17 of Spring Lawn Farm and the accompanying statements. This plan is especially valuable in that it clearly sets out the various crops, rotation schemes, and plans of organizing the farm for comparison as accurate as the available information will allow. This makes it especially useful in the school, where it becomes a means of so standardizing the work that the student can easily follow the work of his fellows.

The effort has been to devise a graphic language adaptable alike to the plan drawn by the student, the stereopticon, and the printed page. Color schemes for designating the several crops and other devices have been tried and discarded for the simple map with the name of the field, the acreage, the crop, and the year all inserted as plainly as print. Even the weight of the heavy farm boundary line and of the field lines have been found matters worthy of some attention as to uniformity. And the use of arrows has been resorted to as a help in at once seeing the order in which the crops "rotate" from one field to another and returning repeat the same order of rotation.

TABLE XIII.—*Student's tabulation of acreages by crops and fields.*

Kind of crop.	1901	1902	1903	1904[1]	1905	1906
Intertilled crops:						
Ear corn				F, O, 86 A		
Fodder corn				M, 40 A		
Potatoes				R, 6 A		
Grain crops:						
Wheat				E, G, 160 A		
Oats				L, 40 A		
Barley				P, I, 46 A		
Flax				A, 80 A		
Rye						
Grass crops:						
Clover seed (second crop).				H, D, 120 A		
Timothy seed				C, 80 A		
Clover and timothy meadow.				H, D, 120 A		
Pasture				N, K, B, 126 A		
Alfalfa						
Annual legumes and catch crops:						
Canada peas						
Rape				F, G, fall, 160 A.		
Millet						
Rye for hay or green manure.				M, S, spring, l. fall, 80 A.		

[1] See key map, fig. 15 (p. 56).

TABLE XIV.—*Student's tabulation of field records.*

Field.	Kind of crop.	1904					
		Gross product.	Yield per acre.	Price per bushel or per ton.	Cost per acre.	Income per acre.	Gain or loss (—) per acre.
	Intertilled crops.						
F	Ear corn.......bushels	2,800	35	$0.35	$11.39	$12.25	$0.86
M	Fodder corn.......tons	160	4	3.00	10.73	12.00	1.27
Farm-S	Potatoes.......bushels	200	100	.30	25.36	30.00	4.64
	Grain crops.						
K	Barley.......bushels	1,056	26.4	.36	9.50	9.50	.00
A	Flax.......do	800	10	1.25	9.91	12.50	2.59
L	Oats.......do	1,200	30	.27	9.65	8.10	−1.55
B	Rye.......do	1,440	18	.47	8.65	8.46	− .19
E, G, and I	Wheat.......do	3,000	15	.70	9.86	10.50	.64
	Grass crops.						
H	Clover hay.......tons	100	2.5	5.00	6.19	12.50	6.31
C	Mixed hay.......do	224	1.4	5.00	6.19	7.00	.81
	Annual pasture.						
O	Millet.......tons	18¾	2.5	4.50	9.18	11.25	2.07

TEACHING FARM MANAGEMENT IN AGRICULTURAL HIGH SCHOOLS.

The conditions of a large agricultural high school, such as those at St. Anthony Park, Crookston, and Morris, in Minnesota, and those in each congressional district in Georgia and Alabama, afford favorable conditions under which farm management can be taught to those who are to become farmers; and also to those who are to teach agriculture in consolidated rural schools, or in the 1-room district school.

The students attend the Minnesota schools named above only in winter, spending the alternate 6 months on the home farm or, if they are not from farm homes, as employees on farms where both the actual farm life and the work of the farm can be learned. The practice in the school at St. Anthony Park has been to include a few lectures on farm planning in the first year and to require each student to make from memory or by visitation to his home a plan of his home farm or of that farm which is best known to him. (See samples of these maps in figs. 18, 20, and 22.)

The second year in the classes in farm management the student is required to make a map, a business statement, and an invoice of the home farm for the intervening year. (See figs. 13 and 14.) The student is then required to make a key map as in figures 15, 21, and 23, setting the beginning of the rotation a few years ahead so as to give time to gradually move fences and lanes, and to transform the old scheme of cropping into the new. He is then required to project a scheme of transition maps for the intervening years, as in figures 13 and 14. He is also required to arrange a system of annual record maps in which to place a record of the crop grown, yield per acre, price, gross income, income per acre, net profit, and such other data as are desired.

In case a soil has long been so subjected to a faulty system of cropping that it is very unproductive, it is often necessary to first utilize a system of cropping which will bring the soil part way up to a productive state before installing a permanent rotation scheme. Thus in Virginia a 2-year rotation of corn and three green-manure crops might be used for 4 or 6 years on very poor soil before installing a permanent 5-year rotation: First year, corn; second year, grain; third and fourth years, grass; fifth year, corn. The 2-year preparatory or soil-building rotation is as follows: First year, corn, with crimson clover sowed among the corn; second year, plow under the crimson clover, sow cowpeas, plow under the cowpeas, and sow rye; the second 2-year crop rotation is begun by plowing under the rye and planting corn.

COMPLEX ROTATIONS.

The variety of conditions which may be met and yet adhere to a system is surprising. The key map as a guide makes more variations of crops practicable than can be devised where no plan is projected forward. With the key map the farmer not only has a history of his cropping, but he can look forward and see how any temporary changes in the crops is likely to affect future crops.

Thus alfalfa can be brought into combination of a 5-year rotation on 6 fields, though the seeding of this crop is so expensive that it does not pay to plant it unless it can be left for several years. The alfalfa can be placed on one field for 5 years, while the other crops can be rotated on the other 5 fields, when the alfalfa can be shifted to one of the other fields and its first field come into the 5-year rotation. Thus we have a 5-year rotation in rotation with a single crop, forming a 5-year complex rotation.

Since the alfalfa can be shifted at the end of 5 years to any other field, its former field receiving the crops of the 5-year rotation, there is little or no complexity about this plan. It will only be necessary to shift the alfalfa to a field where it will not interfere with seeding to grass. In like manner one or more fields of about the same size as those under rotation can be planted to permanent grass mixtures for either pasture or meadow, and when they die out, become weedy, sod bound, or otherwise unproductive another field can be seeded down and the grass field can be plowed up to take its place as one of the rotation fields. Students have no little interest in working out unusual cropping schemes and devising mapping schemes which will clearly display their seemingly difficult propositions.

The basis of fact as to plans of farms, kinds of rotations to be used, crops grown, cost of producing farm products, etc., given in this bulletin is naturally limited in its usefulness in or out of school work in remote States. But the method of teaching here presented will be found helpful and suggestive in all States. And the use of plans of teaching here presented will doubtless help to create a demand for the extension of the cost-keeping investigations developed in connection with this effort to devise methods of teaching farm management.

The methods presented herewith are designed not only to serve as aids to teachers of farm management but also to be used by the practical farmer in organizing or reorganizing his farm. Farm efficiency teachers, commonly known as demonstration farmers, employed at public expense to help farmers reorganize their business will find the key-map scheme of planning and recording the plans of farms most useful. When once the county has a group of farms thus systematically organized in each township or consolidated rural-school district, and the leading facts of yields, profits, etc., are recorded on each for a series of years, the demonstration farmer will truly have demonstrations of entire farms, scientifically managed. Some of these farms will be models both in form and in net profits.

APPENDIX.

INSTRUCTIONS TO STUDENTS.

Each student is required to make a set of drawings of his or her own home farm or of that farm with which he or she is most familiar, following the general plan of those in figures 12 to 14. Make first the first-year plan regarding the present management of the farm, as in figure 12, and then construct a key map, as in figure 15, and fill in the transition maps, as in figures 13 and 14, for each of the intervening years, providing for the actual changing of the old forms of fields and the farm system of cropping so as to bring into operation the new plans of fields, crop rotations, and systems of caring for live stock, as outlined in the key map. Place the rotation key map a sufficient number of years ahead so that under the transition maps the fields can be gradually brought into the permanent scheme of cropping. Should exigencies arise in the farming making it necessary, additional transition maps can be made, longer delaying the full adoption of the key-map plan, thus making it easy to take the longer number of years before bringing the farm entirely under the plan on the key map. Owing to very dry years and other irregularities the key map can not always be adhered to. The history map will show the changes actually made. And sometimes it is necessary to project on transition maps a program for changes for two or more years, then to return to the plan on the key map. When these exigencies show that the plan on the key map is fundamentally wrong or the conditions have changed, a new plan can be projected and a new key map made for the future guide.

Make statements of farm developments and changes which are to be made preparatory to the reorganization of the fields, such as clearing off trees or stones, drainage, irrigation, fencing, and the replanting of groves, thus to determine in the beginning the permanent forms and sizes of the fields. Write out especially noteworthy features of the proposed plan; give the acreage provided for each class of crops in the new plan, preferably in a tabular statement under some such form as that shown in Table XIV. Give an estimate of the number of each class of live stock proposed to be kept under the new plan. Write in detail the faults of the old plan of the farm organization.

Write rotation schemes as follows: Five-year rotation: First year (10 loads manure per acre), corn; second year, grain; third and fourth years, clover and timothy; fifth year, grain. Suggest new ways of expressing plans, drawings, and other details. Devise new schemes of teaching farm management, new plans of rotating crops, and arranging fields, new methods of growing, handling, and using crops. Place the date and your full name on every drawing and paper.[1]

GUIDE FOR STUDENT'S WRITTEN STATEMENT.

JANUARY, 1902.

Figure 12 shows Spring Lawn Farm as it appeared in 1901. It is situated 6 miles southwest of Morris, in Stevens County, Minn., and consists of 800 acres of land, section 29 and southeast quarter of section 30, township 124, range 42 west.

The farm has been devoted largely to grain growing for about 15 years. Only a little manure from the live stock has been added to the soil and but little tame grass or clover have been grown, though these crops have done well when sown. The soil is uniformly a clay loam with strong clay subsoil, with good ability to absorb and retain water, which is supplied to crops in time of drought. In years of unusual rainfall the soil is inclined to be heavy and wet. This map shows that 30 irregular fields have been made by annually breaking one portion after another of the native prairie sod. The quarter section on the west was added to the main farm by recent purchase.

The soil is not readily worked in wet seasons and some portions need drainage. The farm is undulating and natural drainage is provided except on limited areas, and these areas can be drained for the most part with surface drains at slight expense. Some tile drainage will be necessary. The soil is fairly rich, and being rather heavy will not leach and will long show the effects of applied manures.

The rotation key map, figure 15, shows the projected scheme of crop rotation for farm management. The seven 80-acre fields, A, B, C, D, E, F, and G, provide for a seven-year rotation: First year, grain; second year, corn and rape; third year (manure 10 tons), corn and rape; fourth year, grain; fifth year, grass; sixth year, grass; seventh year, pasture, as shown in field A. In field A the grain, with which the rotation statement begins, is in 1904; in B in 1905; in C in 1906; thus down to the last of the seven fields, G, when it is in 1910. Then starting down through the series of seven fields, grain is again in field A in 1911. At the end of the seventh year a new key map can be made in which the rotation sequence stated in the respective fields, as in figure 15, will simply be extended for another period of years.

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[1] The teacher should have a date stamp in the classroom and should stamp the date of receipt on all papers, or, if it is not possible to secure a date stamp, should write the date on each sheet.

The five 40-acre fields, H, I, K, L, and M, are to be under a 5-year rotation: First year, grain; second year, grass; third year, grass; fourth year, grain and rye; fifth year (10 loads manure per acre), corn, planted thickly for fodder, as shown in figure 15. Owing to the fact that some of the fields for this rotation can be prepared for the cropping scheme earlier than others, it is not always practicable to have the initial crop follow in any regular order in adjacent fields. Thus in fields H, I, K, L, and M, the rotation, as stated, begins with grain in 1904 on field I; in 1905 on field M; 1906, field L; 1907, field K; and 1908, field H. This sequence may be shown by arrows leading from the crop used as the initial crop of the rotation and from the field on which the crop is grown each successive year, as in figure 8.

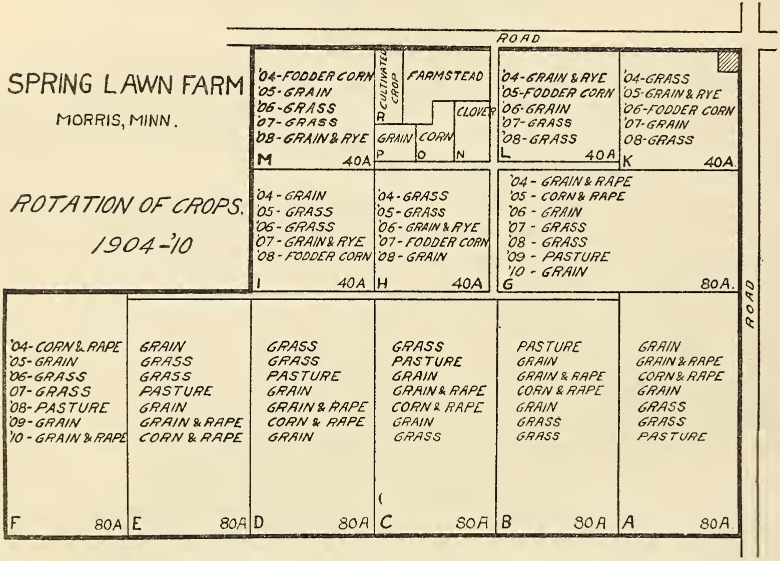

FIG. 15.—Spring Lawn Farm rotation key map. Farm as reorganized with seven 80-acre fields, five 40-acre fields, and four 6-acre fields. Lanes go to all fields. The seven 80-acre fields are to be fenced with a combination of barbed and woven wire, one barbed wire above and two below a 24-inch ribbon of smooth wire. The five 40-acre fields and the six small fields, beside the farmstead, are to be fenced with a 50-inch ribbon of 12-strand woven-wire fencing, with one barbed wire below.

The rotation on the seven 80-acre fields is: First year (manured), corn and rape; second year, grain (4 pounds red clover, 2 pounds alsike, and 8 pounds timothy seeded with the spring grain); third and fourth years, meadow; fifth year, pasture; sixth year, grain; and seventh year, grain and rape. But three fields are to be plowed each year, the field for corn and two fields for grain. One field of grain is sown on disked corn land.

The rotation of the five 40-acre fields is: First year (manured), corn; second year, grain plus 4 pounds red clover, 2 pounds alsike, and 8 pounds timothy; third year, meadow; fourth year, pasture; and fifth year, grain. But two of the five fields are plowed each year, one for corn and one for grain. The corn land is disked for grain.

The rotation of the four 6-acre fields, near the buildings, designed to supply easily accessible pasturage and soilage, is as follows: First year (manured), corn or other cultivated crop, as potatoes or mangels; second year, fodder corn; third year, grain; and fourth year, clover. But three fields are plowed each year.

The four 6-acre fields, N, O, P, and R, besides the farmstead, are to be planted to a four-year rotation; First year (manured 10 tons to the acre), corn; second year, grain; third year, clover; fourth year, cultivated crops, as potatoes, roots, and corn.

Figure 13 shows the transition plan adopted in 1902 for Spring Lawn Farm, to be used for that year with the old field lines, for the most part, still remaining. The crops, however, are planted with relation to the future lines of the fields, as shown in figure 15, that the land may be uniformly prepared on each respective field for the crop which is to follow. Under this plan all native hay land is to be broken this year.

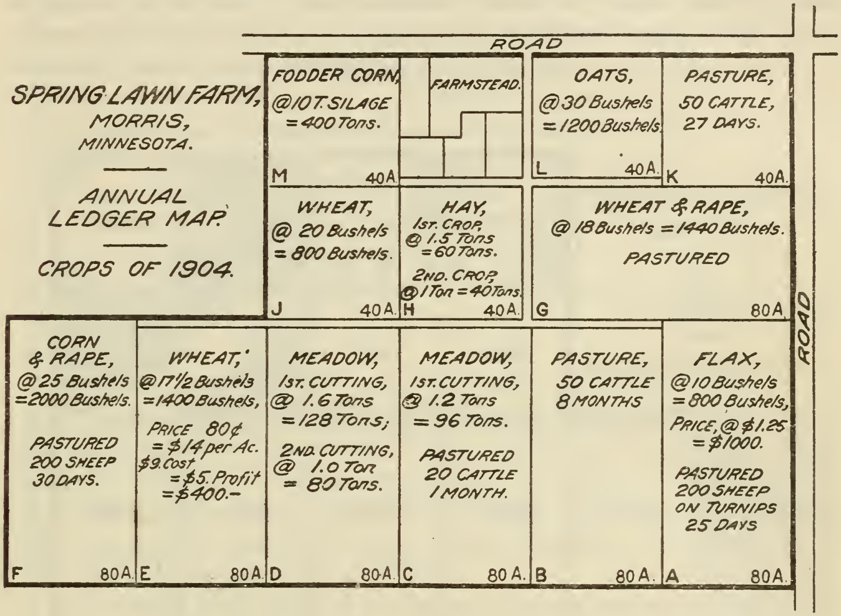
ROAD
SPRING LAWN FARM,
MORRIS,
MINNESOTA.
ANNUAL LEDGER MAP.
CROPS OF 1904.
FODDER CORN, @10 T. SILAGE = 400 Tons.
M 40A.
FARMSTEAD.
OATS, @30 Bushels = 1200 Bushels
L 40A.
PASTURE, 50 CATTLE, 27 DAYS.
K 40A.
WHEAT, @ 20 Bushels = 800 Bushels.
J 40A.
HAY, 1st. CROP, @ 1.5 Tons = 60 Tons.
2ND. CROP, @ 1 Ton = 40 Tons.
H 40A.
WHEAT & RAPE, @ 18 Bushels = 1440 Bushels.
PASTURED
G 80A.
ROAD
CORN & RAPE, @ 25 Bushels = 2000 Bushels.
PASTURED 200 SHEEP 30 DAYS.
F 80A.
WHEAT, @ 17½ Bushels = 1400 Bushels,
PRICE 80¢ = $14 per Ac.
$9. Cost = $5. Profit = $400.–
E 80A.
MEADOW, 1st. CUTTING, @ 1.6 Tons = 128 Tons;
2ND. CUTTING, @ 1.0 Ton = 80 Tons.
D 80A.
MEADOW, 1st. CUTTING, @ 1.2 Tons = 96 Tons.
PASTURED 20 CATTLE 1 MONTH.
C 80A.
PASTURE, 50 CATTLE 8 MONTHS
B 80A.
FLAX, @ 10 Bushels = 800 Bushels,
PRICE, @ $1.25 = $1000.
PASTURED 200 SHEEP ON TURNIPS 25 DAYS
A 80A.

FIG. 16—Spring Lawn Farm. General annual ledger data, by fields.

In figure 14 is shown the transition map of this farm as planned for 1903.

The purpose carried out in the new plan, projected on the key map in the figure 15, is to secure wheat, flax, or other small grain from two of the three 80-acre fields and from one of the 40-acre fields, also some timothy and clover seed, and to use the corn, the pasture, the hay, stubble, straw, and other roughage, as well as some of the small grains, in the production of cattle, hogs, and horses for sale. It is designed gradually to develop a business in pure-bred live stock and in pure-bred seeds.

Each field should have a permanent name or number. Letters generally best serve the purpose because they are simpler to place on the maps and on tabular statements. Thus, on the key map the letter used as the name of a field can be placed on the lower left-hand corner and the figures representing the acreage, followed by the letter A, can be placed in the lower right-hand corner.

It is sometimes convenient to designate each rotation and the fields it occupies. Thus, on Spring Lawn Farm the three rotations may be designated as the 7-year, the 5-year, and the 4-year rotations. On a farm where there are two 4-year rotations each rotation can be given a number; thus, rotation 1 and 2, or better, a proper name, thus—grass rotation, grain rotation, or other name suggested by some permanent feature in the rotation scheme, often the name of the principal product sold, as wheat rotation or dairy rotation. On a farm where the rotation is centered about the production of potatoes that rotation could be known as the potato rotation. A temporary rotation to rid the farm of quack grass or other persistent weed might be known as the weed rotation.

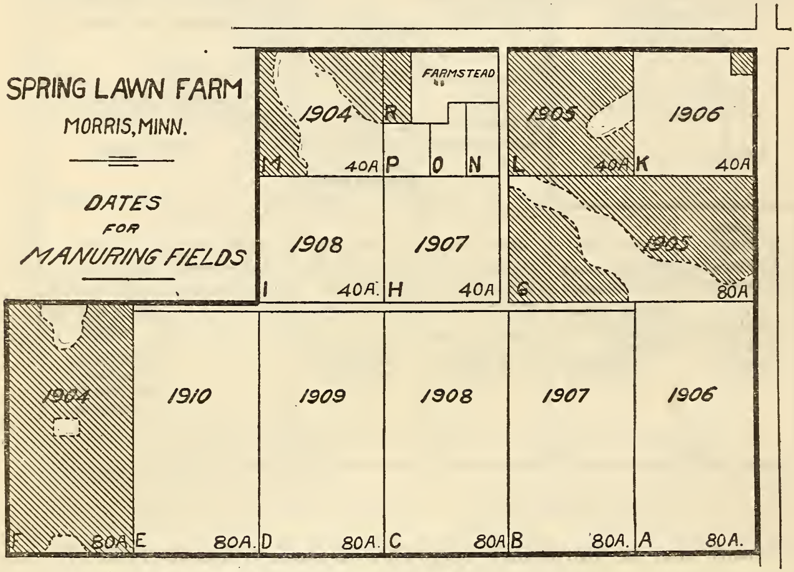

FIG. 17.—Spring Lawn Farm. Manuring schedule shown by dates in each field; also showing the higher places in fields where manure has been actually placed. A new blank must be used as often as the shortest rotation is completed.

FARM PLANS MADE BY STUDENTS.

Below are given plans of 17 farms made by students, in each case presenting the farm as it was before reorganization and the projected plan for reorganization. These are chosen to show typical farms and to demonstrate the fact that most Minnesota farms are not well organized and that far better plans can be made. These specific problems were chosen from those presented by students in the classes in farm management in the St. Anthony Park Agricultural High School and in collegiate classes in agriculture at University Farm, and were selected from plans made between the years 1900 and 1905. To save space and avoid repetition, the students' notes and instructor's criticisms have been cut down to those features needed to describe the drawings or to bring out only the features presented in the successive steps. Each student was expected to discuss his own farm in full from the standpoint of the various features mentioned throughout all these statements.

Only in rare cases, where the farm was very irregular or where there were many things in a state of transition, was the student baffled, and the only help needed was a general start at a scheme of planning the farm. Not only the boys but the girls also usually found no serious difficulty in making good paper plans of their home farms. In many cases the students were able to consult with their fathers and finally to make plans in which the judgment of the student and parent were combined and to which the teacher could give assent.

Students from the city, and especially city girls, could do little with this subject, sharply illustrating the value of the wide experience gained by the farm youth. No case has come under the author's attention where a student experienced in country life or a teacher who has really entered into this work has failed to become enthusiastic over the possibilities of improving the plan of farming through the better arrangement of the farm.

It is found that persons trained in the mechanical or engineering side of this question can greatly assist the farmer in getting his own knowledge and ideas of his own farm conditions systematically arranged by means of drawings and tabular statements, and so recorded that they will be fully understood and may readily be followed through a long series of years, and that permanency of plan may be established in his farm business.

Figures 18 to 59 give plans showing the students' home farms as drawn by the pupils during their first year at the St. Anthony Park Agricultural High School. Also, key maps projecting the reorganization of these same farms under systems of rotative cropping and live-stock production, projected permanently forward, are shown. Students receiving a series of lectures on farm management and field crops, accompanied by the required work in making plans, following the scheme outlined above, have been quite as uniformly successful in securing creditable pass marks for work of this kind as for any other studies in the curriculum. The teachers have thus been able to demonstrate that the subject of farm management may be successfully taught in the first years of a high-school course to farm youths who have had a practical farm experience.

The instructions to students given above are to be followed by each student in preparing plans for class work. The several plans presented by each student may be graded under such a system of letters or numbers as the teachers may choose for other exercises. Since these plans serve to test the students' general comprehension of the philosophy of farm management and also to test their accurate knowledge of the practical application of farming, they, including the written statements accompanying the drawings, may properly serve as a large portion of the term tests in work of this sort.

STUDENTS' FARM PLANS.

Bluegrass Farm.

[Statement of Chas. E. Grannis, figs. 18 and 19.]

Bluegrass Farm is located at Vernon Center, Blue Earth County, Minn., and contains about 160 acres, including the railroad which runs through it. It has been rented for many years and is not in as good condition in regard to drainage as it should be. The house is not used at present. The barn and granary are used for storing hay and grain. There is a good grove, and the orchard still produces a moderate amount of fruit, although the trees are getting rather old. The permanent pasture is a strong feature of the place. Since it is rather low, the soil always contains plenty of moisture. It is a bluegrass and white clover sod and holds up with surprising persistence in the driest weather. During the summer of 1892 it pastured about one head per acre, and there seemed to be plenty of feed. The cattle pass under the railroad through the creek at X, indicated in the plan. There are but two places on the farm which are too wet to be plowed, and these are cut for hay, the grass on them being of good quality. They can be drained very cheaply, however.

THE PROPOSED PLAN.

Under the new plan (fig. 19) the tillable land is divided into four 32-acre fields, on which a 4-year rotation will be run as follows: First year, corn; second year, barley; third year, clover; fourth year, oats. The fields are larger than can be manured every 4 years, and hence the manure can be applied each year to 16 acres, or one-half of the field that is in corn. Thus, for example, during the winter and spring of 1903 the north half of Field A will be manured; in 1907, when the same field is again in corn, the south half will receive manure. Thus the land will all be manured once in 8 years. Since each field raises a crop of clover every fourth year, the clover and the manure should keep up the productivity of the soil.

By fencing the four fields, A, B, C, and D, rape can be sown with the grain crop each year, and some pasturage can be secured from the clover field. The 64 acres of supplementary pastures will thus yield good pasturage every year. Plans are under consideration for changing the location of the farmstead, as shown in figure 19.

INSTRUCTOR'S CRITICISM.

The character of the soil should be stated, also the kind and amount of live stock kept. The rotation plan is feasible. Better results might be secured were you to transpose the oats and corn, thus planting corn instead of oats on clover sod. However, if you experience difficulty in getting a catch of clover, your plan may be the better, as with your arrangement you seed down with the barley following a crop of corn, which gives a better seed bed in which to get a catch of clover. As you have the arrangement, your difficulty will probably be in the oats lodging when sown on the clover sod.

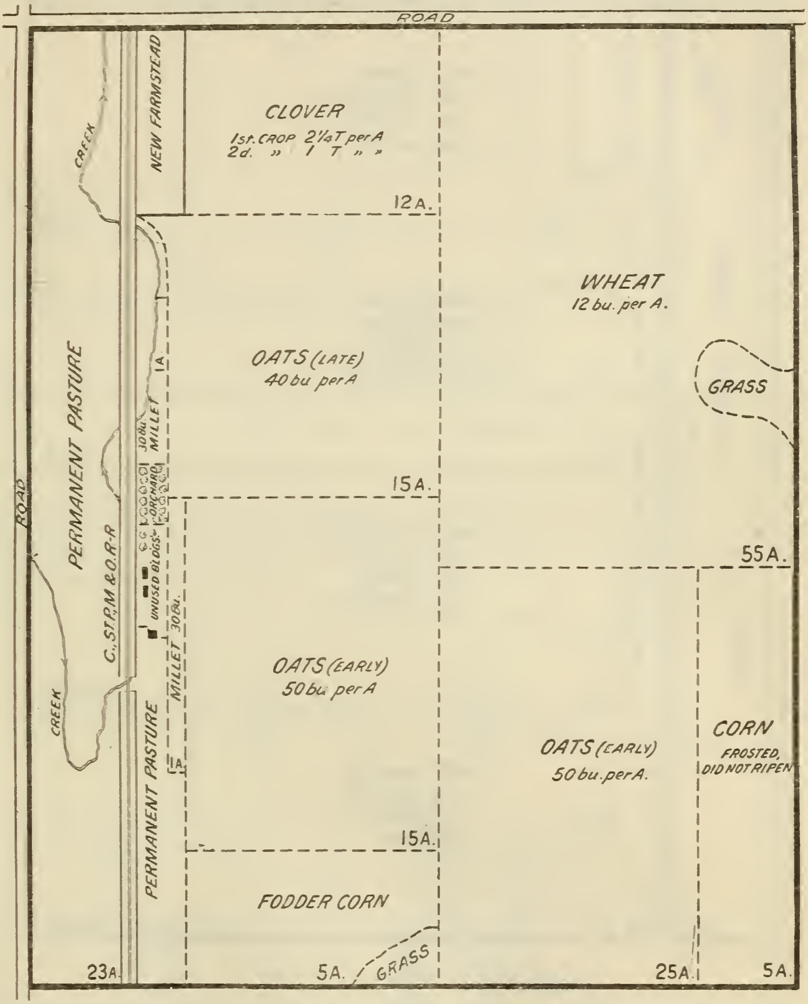

FIG. 18.—Bluegrass Farm. Original plan.

The 30 or 35 head of stock which can be pastured on the permanent pasture, supplemented by catch crops in the rotation fields, are needed to keep up the productivity of the 4 fields. This number of live stock would produce enough manure to cover 1 of the 4 fields each year with a dressing of from 8 to 10 loads per acre. Manuring every 4 years and the crop of clover will increase the productivity of the soil, permitting you to sell some grain as well as live-stock products.

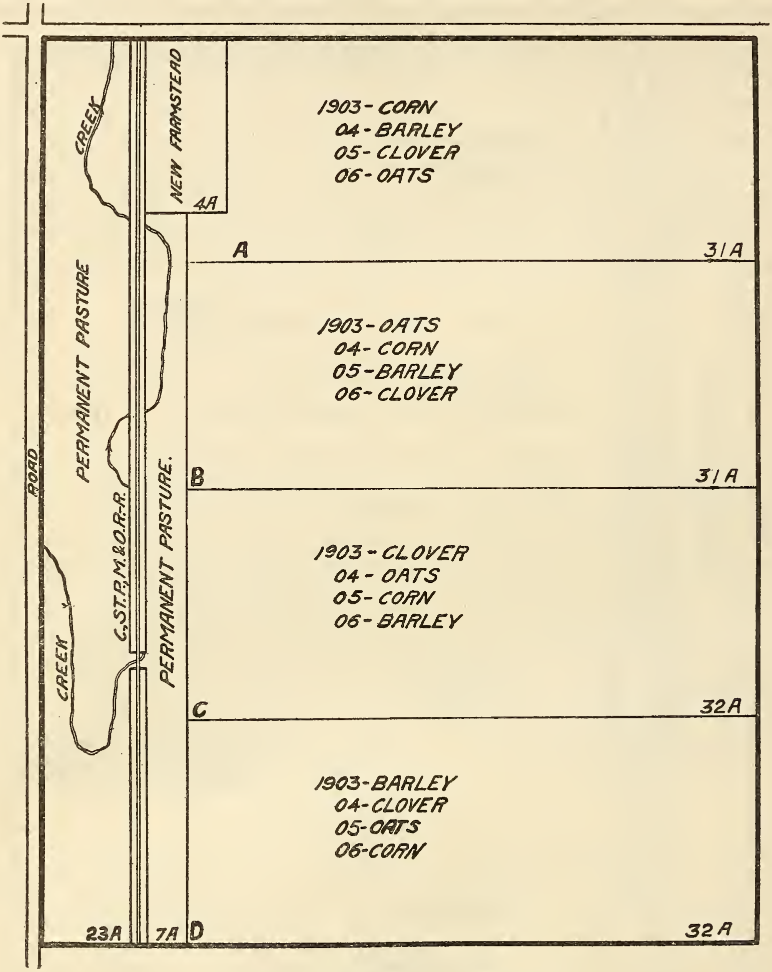

FIG. 19.—Bluegrass Farm. New plan.

POWELL FARM.

[Statement by Leonard Powell, figs. 20 and 21.]

This 280-acre farm is located near the town of Marshall, in Lyon County, Minn. The fields are nearly level, the wetter land sloping enough toward the west so that all waste water is carried away by a large open drain. The small slough near the barn can easily be drained by running a tile drain to the public road, then westward about 30 rods. The buildings are a good house, a horse barn, granary and cattle shed, hog house, and sheep shed. The line of farming carried on has been that of grain raising and stock feeding, the wheat and flax being usually sold soon after thrashing, while the barley, corn, and oats are fed on the farm.

The live stock kept are cattle, horses, sheep, and swine, the horses being raised only for carrying on the farm operations. About 75 head of cattle are kept the year round and fed for beef. Somewhere near 400 head of sheep are bought in the fall and pastured on the stubble fields, enough corn and mill stuffs being fed also to put them in good market condition after a short period of yard feeding in the late fall. One hundred head of pure-bred Poland-China swine are raised each year, the best being sold for breeding stock and the remainder fattened for market. The farming operations require about 12 head of horses.

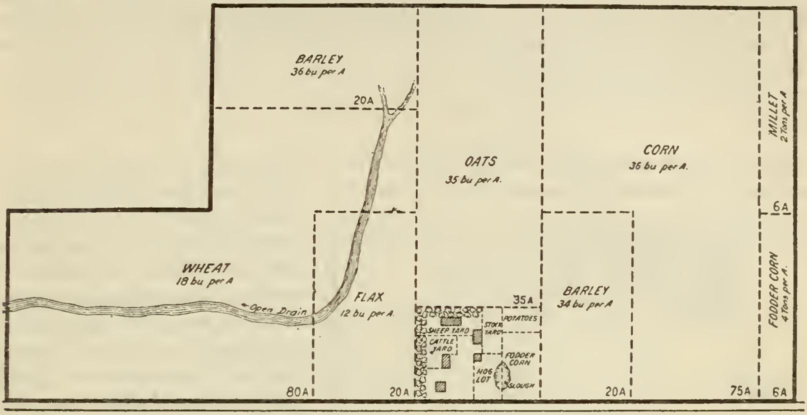

FIG. 20.—Powell Farm. Original plan.

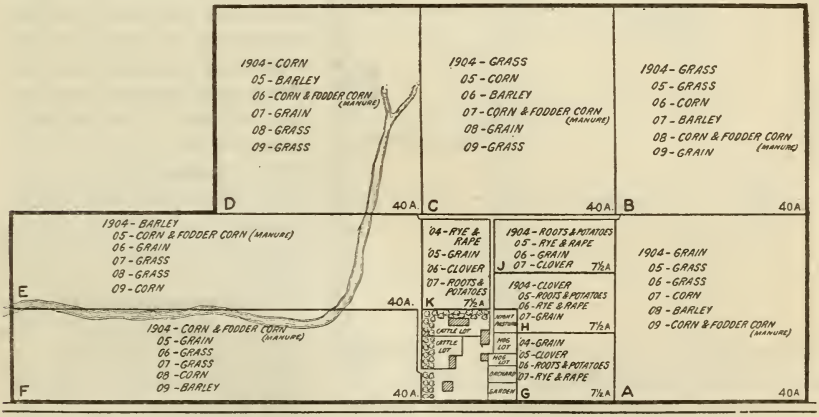

FIG. 21.—Powell Farm. New plan.

THE NEW PLAN.

No definite rotation has ever been followed, as shown in figure 20. In the proposed new plan shown in figure 21 the fields are slightly altered for 1903, so as to bring the farm into a definite 6-year rotation in 1904, with six 40-acre fields of equal size. The rotation provided on the 6 fields is as follows: First year (manure), corn; second year, grain; third and fourth years, grass; fifth year, corn; sixth year, grain. It will be noticed that the 6 fields used for the larger rotation are so arranged as to reduce the cost of fencing almost to the minimum and so that each is easily accessible from the buildings.

The 40-acre field from which the farmstead is deducted is divided into four equal plats, upon which a minor rotation is to be grown for hog pasture, root crops, and similar uses, the rotation being: First year, grain; second year, clover; third year, roots and potatoes; fourth year, rye and rape.

INSTRUCTOR'S CRITICISM.

Your plan appears feasible, except that you have not provided enough pasture for the amount of live stock you are planning to keep. You have provided 80 acres of grass in your 6-year rotation, presumably 40 for hay and 40 for pasture. You have provided 7½ acres of rye and rape and 7½ acres of clover in your 4-year rotation. You can plant rape among your corn and barley and even among your corn and fodder corn, thus making much tame pasture in your 6-year rotation. The alternative would be to let the grass lie 3 years and then choose for the sixth field as to whether it should be in corn or barley or other grain, or part in corn and part in grain. Your 6-year rotation would thus be stated as follows: First year (manure), corn and fodder corn; second year, grain; third year, fourth year, fifth year, grass; then corn or grain. Your statement indicates that you have been keeping considerable stock, but your original plan does not show pasture for a sufficient source of roughage for so large a number of animals.

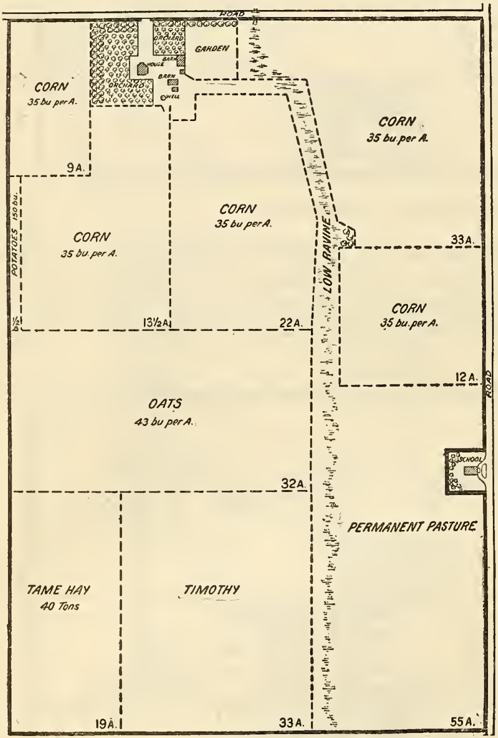

FIG. 22.—Keogh Farm. Original plan.

The arrangement of the fields in both rotations is good. You fail to state whether the open ditch is such that you can conveniently work across it or must turn at the ditch. The fields might be more conveniently worked if a tile drain were practical unless you can work across the open ditch.

Since it will not always be practicable to sow rye following roots and potatoes in your 4-year rotation, corn and rape may be substituted for rye and rape. It will be observed that you can easily replace part or all of the roots and potatoes with corn and rape. These fields of corn and rape can be profitably hogged off.

KEOGH FARM.

[Statement by G. F. Keogh, figs. 22, 23, and 24.]

This 240-acre farm, situated near Le Roy in Mower County, southern Minnesota, is all tillable, except a low wet ravine running through the farm lengthwise, as indicated on the maps. The land is rich and in good farming condition. The place is well equipped with buildings for hog and cattle raising, which is the main line of farming carried on, the grain products being fed on the farm. About 200 hogs and 25 to 30 steers are fattened each year and considerable breeding stock is kept. No rotation has been followed, part of the farm being sowed to permanent pasture; the fields near the buildings have been planted to corn so that they might be partially pastured, and the farther fields have been planted to grain and hay. (See fig. 22.)

THE NEW PLAN.

A 5-year rotation is planned, however, beginning with 1905 on five 30-acre fields, and a 4-year rotation on four 5-acre fields, as shown in figure 23. One intermediate year will be required in order to get the grass in the right fields in both rotation schemes. The larger fields are divided as nearly equal as possible and the low ravine is used for a lane for stock and vehicles between fields. This lane is wide enough so that one can drive on either side of the wet ground, and the idea is to pasture it that the use of the land may not be lost. The main rotation consists of: First and second years, corn; third year, oats; fourth and fifth years, grass. The minor rotation of four 5-acre fields is planned for summer pasturage for hogs until the corn is ripe, when they can be turned into corn in one of the large fields. This rotation is as follows: First year, corn; second year, potatoes; third year, roots; fourth year, pasture, the manure to be applied to the pasture.

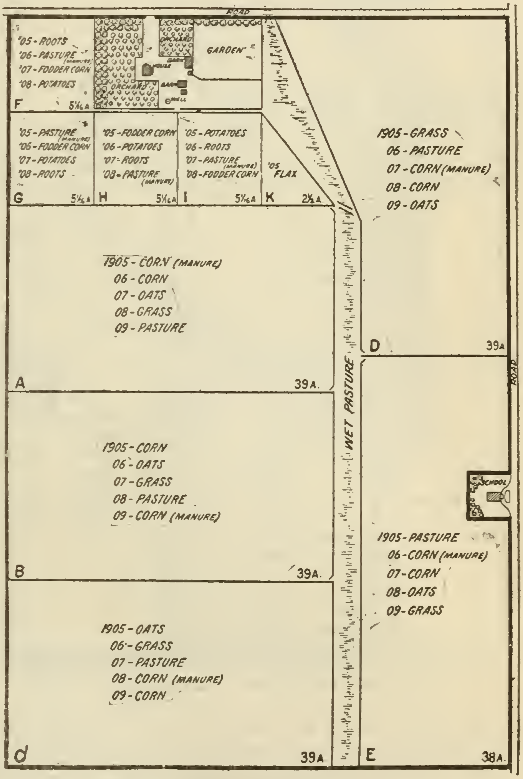

FIG. 23.—Keogh Farm. Student's plan.

INSTRUCTOR'S CRITICISM.

The major rotation is very good both in arrangement of fields and system of cropping. The use made of the ravine is excellent. The minor rotation is poorly arranged. The fields are rather too small for the number of hogs proposed to be kept and the cropping system is not well suited to your needs. You are planning to grow three cultivated crops in succession with no crop with which to seed down for pasture. This would necessitate using annual pasture crops which are expensive to grow and not as much benefit to the soil as clover. Five acres would not thus furnish sufficient pasture for 200 hogs. Your minor rotation fields should contain

8 or 10 acres. Your rotation might be arranged on some other plan. Would suggest that you set aside 40 acres for your minor or hog rotation, as shown in figure 24. On the four 10-acre fields the following four-year rotation would be suitable for your purposes: First year, grain; second year, clover; third and fourth years, corn and rape to be hogged off. If desired, part of the land assigned to corn can be used for such annual pasture crops as rye followed by rape. The 10 acres of clover would furnish much pasture for the hogs. The 5-acre, three-cornered strip across the ravine from the farmstead might be seeded to alfalfa or other crop for soiling. Two 35-acre fields on the east side of the ravine and three 32-acre fields on the west side might be used for the same 5-year rotation for which you planned.

It is not wise to try to raise hogs without ample pasture, as pasture greatly reduces the cost as does also the hogging off of corn. As three of these fields, one for clover and two for corn, will be pastured each year, good use will be returned for the expense of fencing these four fields.

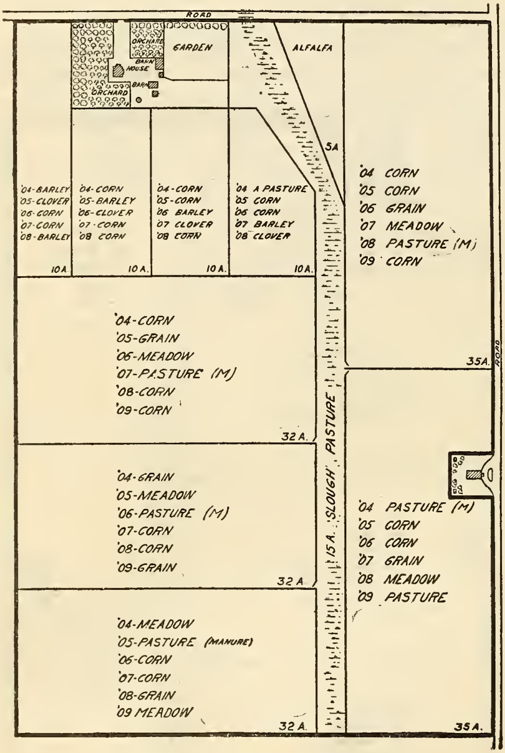

FIG. 24.—Keogh Farm. Revised plan.

LAKESIDE FARM.

[Statement by Robert L. Ott, figs. 25 and 26.]

Lakeside Farm consists of about 160 acres situated near the city of Albert Lea in Freeborn County. This land is touched by two railroads, one passing the southeast corner and one running east and west, cutting the farm into two parts. The tillable land is all tile drained, as indicated in figure 25. The land marked pasture is rather wet and allowed to grow timber. The farm is well supplied with buildings, consisting of a house, barn, granary, hog house, henhouse, woodshed, and machine sheds. Diversified farming is followed and proves quite profitable, both grain and animal products being marketed. Considerable live stock is kept the year around, 20 head of milch cows are kept and about 30 head of steers are fed each winter. A number of hogs are marketed each year; the corn crop, which is the largest crop, is mostly fed on the farm. Only enough horses are kept to carry on the farm work.

THE PROPOSED PLAN.

No definite rotation has been followed. An attempt has been made to kill the quack grass in the southwest corner by continuous cropping to corn. For this reason a year will be skipped before the proposed rotation is started. A 6-year rotation is planned, as shown in figure 26, on 6 fields of 20 acres each. Fields A and J are to be cropped as one of the fields of the 6-year rotation. The rotation is to consist of: First year, corn; second, third, and fourth years, grain; fifth and sixth years, grass. The minor rotation is to be carried on on 3 plats of 5 acres each and will be used entirely for hog pasture as each crop comes into season. Cattle can reach the lake from the farmstead by passing under the railroad track just west of the farmstead.

INSTRUCTOR'S CRITICISM.

The plan shown in figure 26 is quite feasible. The form, size, and arrangement of the fields are as good as possible under the conditions. By pasturing the 20 acres of grass the second year, together with the permanent pasture and catch crops, sufficient pasture may be supplied. Twenty acres of hay and 20 acres of grass and stubble would hardly furnish the roughage for all the stock you are planning to keep and it may pay, at least in some years, to allow the grass to lie another year, thus reducing the amount of land for grain. Or, since you have abundance of manure, it would pay to replace one of your grain crops with ear and fodder corn. Would suggest the following 6-year rotation: First year, corn on grass sod; second year, oats; third year, (manure) corn; fourth year, wheat or other grain; fifth and sixth years, pasture. Some of the annual product of manure can be used as top dressing on the pasture.

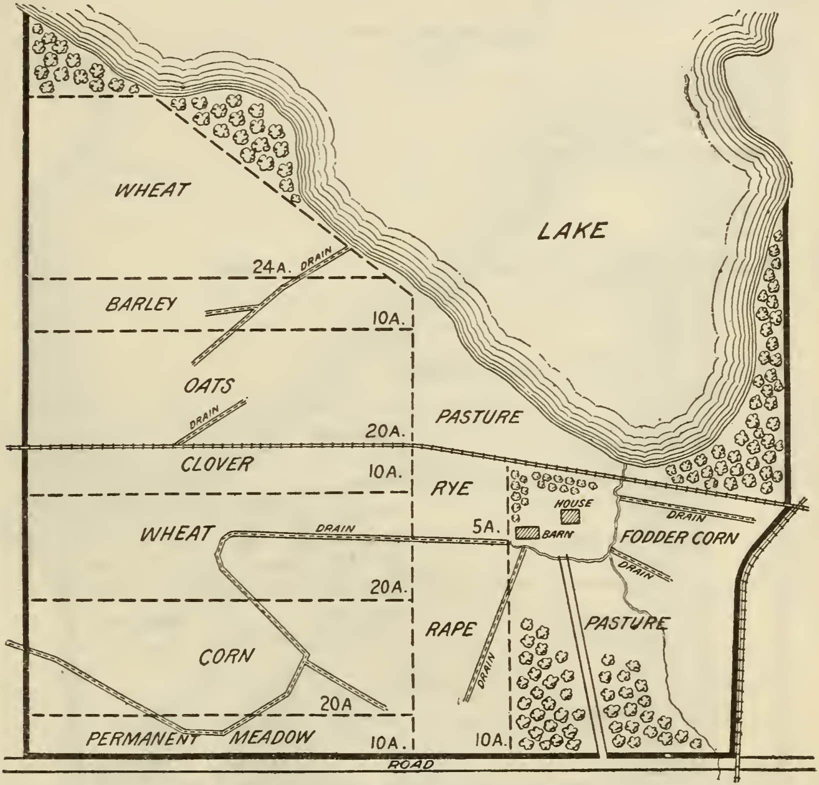

FIG. 25.—Lakeside Farm. Original plan.

Should you care to practice hogging off corn you might change your three fields to four fields of about 4 acres and substitute the following 4-year rotation: First year, grain; second year, clover; third year, corn and rape; fourth year, corn and rape. Under this plan you would use your hog fencing three years out of four and thus get much pasturage.

Martinson Farm.

[Statement by H. R. Martinson, figs. 27, 28, and 29.]

The farm of 160 acres shown in figure 27 is situated 2 miles from the town of Sacred Heart, Renville County, Minn. The public road runs through it north and south, separating the two eighties. The land is all tillable, though a few acres would be benefited by tile drainage, they being somewhat wet in the spring. These fields can easily be drained at small expense. The buildings are fairly good and consist of a house, barn, and granary.

The old style of grain farming has been gradually replaced by diversified farming, the soil having become so impoverished by the production of wheat and flax that a change was necessary.

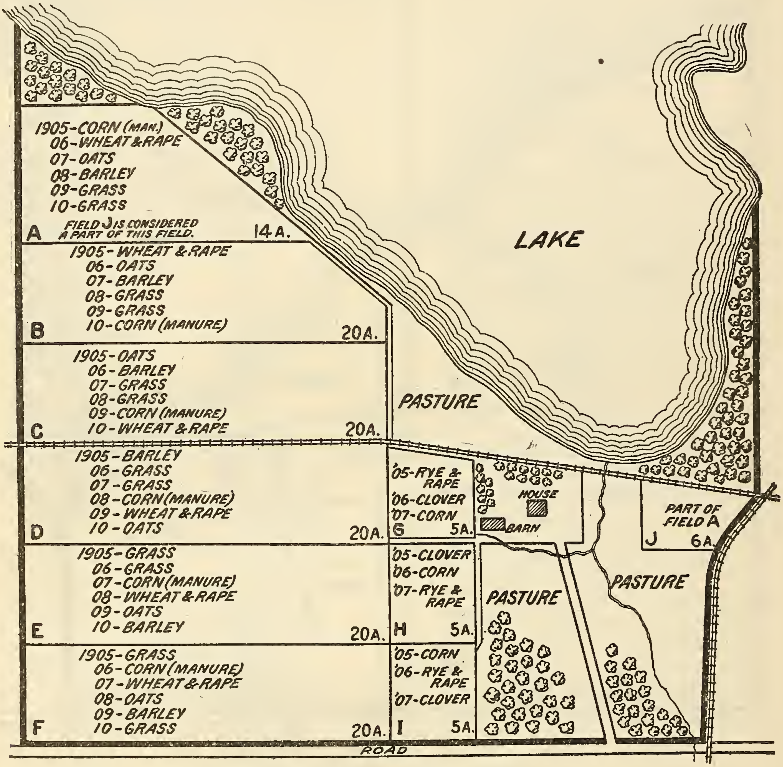

Fig. 26.—Lakeside Farm. New plan.

There is a good creamery in Sacred Heart, and it has been found profitable to keep 15 head of dairy cattle, and 100 head of hogs are marketed each year. Only 5 horses are kept for operating the farm. No system of crop rotation has been followed up to the present time, but for the two years past a large part of the land has been set aside for pasture, grass, and cultivated crops, with a view to getting the soil in better condition for a rotation.

THE NEW PLAN.

As no intermediate state is necessary, the rotation suggested in figure 28 may be started immediately. The farm is divided into eight 20-acre fields, one for the farmstead and minor rotation and the other seven for the major rotation, consisting of: First year, grain; second, third, and fourth years, grass; fifth year, grain; sixth year, corn; and seventh year, grain. It is planned to keep enough stock to consume all the products of the farm excepting the flax, which will be sold on the market. The farmstead will consist of 4 acres, and the minor rotation will occupy four 4-acre fields. These will be used for raising fodder corn and for hog pasturage, under the following rotation: First year, fodder corn; second year, barley; third year, rape; fourth year, clover for hog pasture.

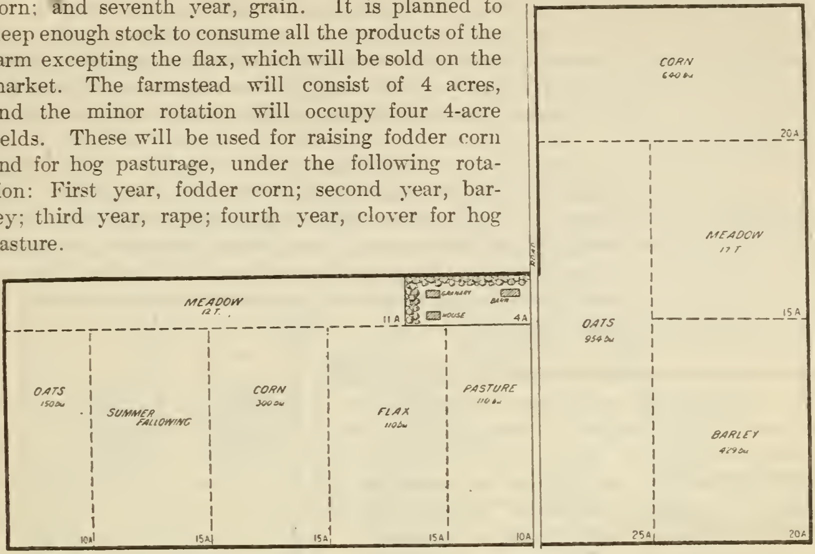

FIG. 27.—Martinson Farm. Original plan.

INSTRUCTOR'S CRITICISM.

Your plan of rotation on the seven 20-acre fields is good, except that it might be better to transpose the oat and corn crops, letting the oats follow flax and corn follow oats. This would allow you to sow grass seed with barley on the corn land, which is very often an advantage over seeding on fall-plowed grain stubble. It is not clear from your plan how you can get all the fields west of the house seeded and ready for pasture so soon, as some of this land was in corn the previous year and could not well have been seeded. The arrangement of fields in both rotations can be improved by changing to the plans shown in figure 29. The form and arrangement of the fields in figure 28 make the fields D and F very inconvenient, and a great deal of time would be wasted in getting to and from them. A large amount of lane fencing is also necessary in getting the stock to and from pasture in these fields, as compared with the plan in figure 29.

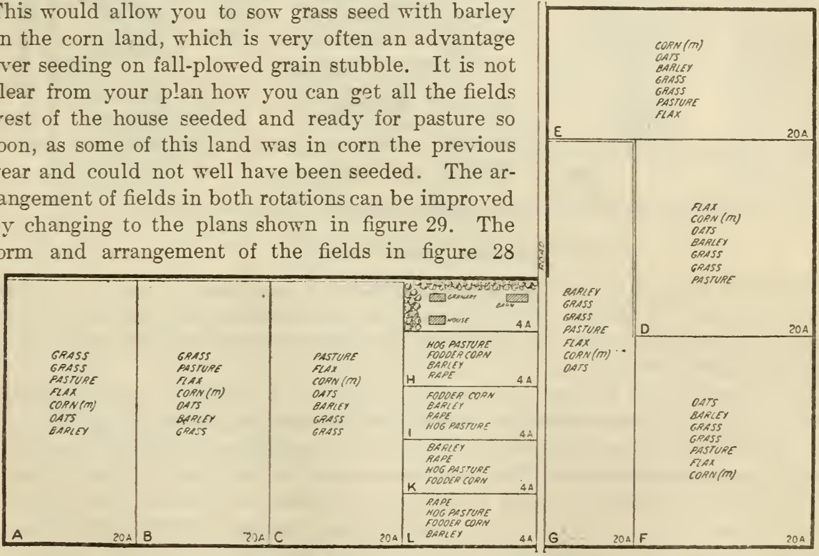

FIG. 28.—Martinson Farm. Student's plan.

The change in the fields on the west 60 acres requires, including the lane, 40 rods more fencing than your plan, but field C is as near the farmstead as before, field B is 30 rods nearer, and field A is 43 rods nearer. If the number of trips made to one of these fields during the seven years of the rotation were determined and multiplied by 43 rods, the saving made by having one end of the field as near as possible to the farmstead would be appreciated. It must be admitted, on the other hand, that more transition years will be required to bring the fields under the rotation scheme if the change is made according to the plan in figure 29.

The minor rotation in figure 28 is poor in grading and arrangement of fields. The advantage of the rearrangement of these fields in figure 29 is very easily seen. You are planning to follow rape with a hog pasture, which of necessity must be of annual crops, which are more costly and less desirable than clover, which ordinarily is preceded by a grain crop. The following rotation is suggested, as in figure 29: First year, grain; second year, clover; third year, potatoes, garden, corn, and rape; and fourth year, corn.

The farmstead should be radically remodeled. The barn appears to stand between the house and the road. This is a most undesirable arrangement, as i does not allow for barnyards in front of the house or in the grove back of the barn. It also shuts off the view of the road and destroys the possibility of artistically arranging the lawn. The position of these two buildings might properly be changed.

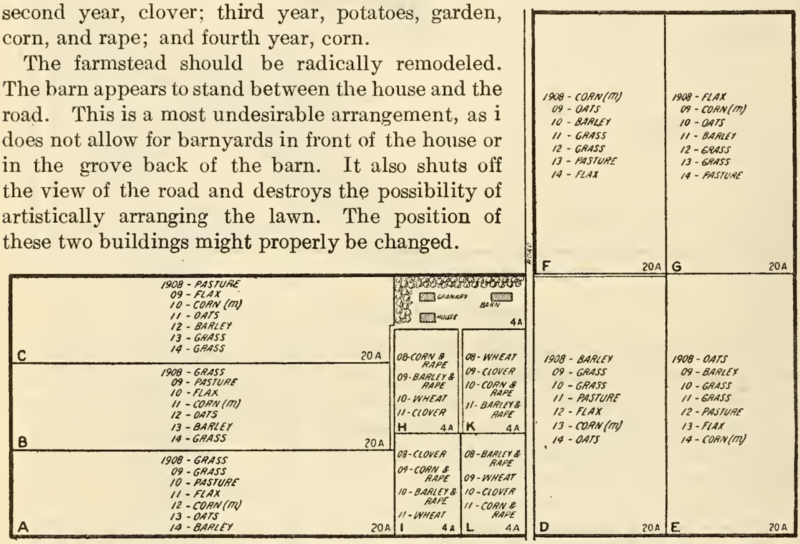

FIG. 29.—Martinson Farm. Revised plan.

CLOVERDALE FARM.

[Statement by David Boss, fig. 30.]

Cloverdale Farm consists of 200 acres, located in central Wabasha County, 5 miles from the village of Zumbrota, on the Chicago, Milwaukee & St. Paul Railway. The soil is a fairly good clay loam, not sandy or stony, and the farm is fenced on all sides with a permanent fence.

There is provided a 10-acre permanent pasture about a small lake near the farmstead. Three small 5-acre fields, K, L, M, have a 3-year rotation: First year, fodder corn; second year, annual crops for green manure or for pasturage; third year, potatoes, mangels, and other root crops. The four 10-acre fields, G, H, I, and J, have a 4-year rotation: First year, wheat; second year, hay; third year, corn; fourth year, barley. The six 20-acre fields, A, B, C, D, E, F, have a 6-year rotation as follows: First year, oats and seed down to clover and timothy; second year, hay; third year, pasture; fourth year, corn; fifth year, wheat; sixth year, barley, and apply barnyard manure on the stubble in the fall before plowing.

I would plan to keep about 30 to 35 head of cattle. I would not keep over 25 to 30 head of sheep, about 40 to 50 hogs, and 7 or 8 head of horses. If the 20 acres of rotation pasture in the 6-year rotation and the 10 acres of permanent pasture on field N failed to furnish feed enough, I should take a crop out of the 4-year rotation and seed to some forage crop to use as sheep pasture.

I do not know the average yield of corn, but would cut the corn for ears and stover and feed most of it to live stock. Wheat yields on an average about 12 bushels per acre; 20 acres at 12 bushels equals 240 bushels, of which 45 bushels would be required for seed the following year and about 30 bushels for bread. The remaining 165 bushels would be sold at the average price of about 80 cents per bushel, or $132.[1]

Barley averages 30 bushels per acre; 20 acres at 35 cents per bushel equals $210. I would keep the barley grown on the 10-acre field in the 4-year rotation for feed and seed. Oats average 35 bushels per acre; 20 acres yields 700 bushels, used mostly as feed for live stock, either whole or ground. Hay averages about 2 tons first crop and 1 ton second crop, making a total of 3 tons per acre. The 20 acres yields 60 tons of hay. I would feed this and sell what hay is raised on the 10-acre field in the 4-year rotation plat. Twenty acres of pasture will support the live stock. I would hope to sell 10 head of cattle each year at an average of $28 per head. I would try to sell 25 lambs each fall at an average of $4.50 each. Would sell about 30 hogs each year at $10 each.

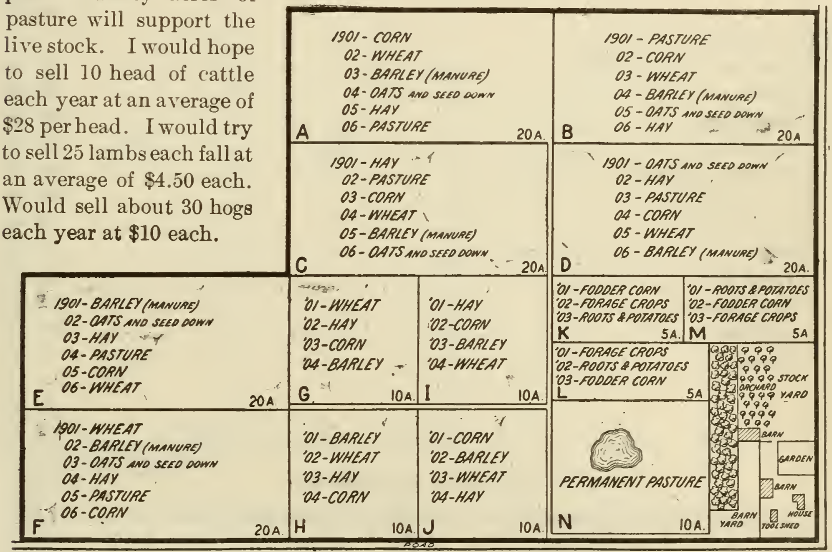

FIG. 30.—Cloverdale Farm. Revised plan.

FOUR-YEAR ROTATION ON FIELDS G, H, I, AND J.

1901. The wheat from these 10 acres will all be sold. Twelve bushels per acre is 120 bushels. At 80 cents it equals $96, bread and seed having been taken from the 20-acre field.

1902. Hay yields on 10-acre plat 2 tons per acre. Would yield 20 tons and would sell at $4.50 per ton, or $90.

1903. Would sell corn from 10-acre field and buy such feeds as bran, shorts, and oil cake for feed. Ten acres of corn, average 50 bushels per acre, gives 500 bushels. This, at 25 cents per bushel, brings $125.

1904. Barley on 10-acre plat yields 30 bushels, making a total of 300 bushels. Would use this for feed and for seed. On the 3-year rotation on fields K, J, and I would plan to raise about 3 acres of potatoes each year. Averaging 150 bushels per acre, they would produce 450 bushels. Would use 150 bushels for seed and feed, and the balance of 300 bushels sold at 25 cents per bushel would bring $75. The remainder of the crops grown on this 15 acres would be used as feed. I would plan to sow rape with wheat, with which no grass and clover are sown, and use it for fall pasturage.

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[1] Figures and prices used in 1900 to 1905.

1903, cash received:	
From corn on 4-year rotation, field G	$125.00
From hay on 4-year rotation, field H	90.00
From wheat on 4-year rotation, field M	96.00
From wheat on 4-year rotation, field B	132.00
From barley on 4-year rotation, field A	210.00
From cattle on pastures and feed	280.00
From sheep on pastures and feed	112.50
From hogs on pasture and feed	300.00
From potatoes on 3-year rotation	75.00
(Income from cows for milk omitted; poultry and dairy products offset groceries.)	
	1,420.50
1903, expenses:	
Live stock	75.00
Fencing	50.00
Machinery	200.00
Insurance	50.00
Personal expense	100.00
Dry goods	200.00
New seeds	50.00
Fuel	50.00
Hired help	200.00
Thrashing bill	40.00
Sundries	100.00
Taxes	60.00
	1,175.00
Net gain	245.50

INSTRUCTOR'S CRITICISM.

This description of Cloverdale Farm and farm business illustrates very clearly how easy it is to get a comprehensive idea of the farm processes or the business of the farm if it is outlined according to some systematic plan permanently projected forward. It is well understood, of course, that there are many conditions which can not be taken into account, such as poor crop years or ravages from insects. Nevertheless, in the long run the man who can obtain as comprehensive a view of his farm as is here indicated has a great advantage.

On the three 5-acre fields, K, L, and M, it would seem better to provide pasture crops rather than annual forage crops, which would change the rotation to: First year, barley, seeded to clover; second year, clover pasture; third year, fodder corn and rape. As the 3-year rotation is essentially a swine and forage rotation, it is believed the suggested plan would greatly cheapen the cost of caring for the pigs. The clover will furnish pasture for the growing pigs throughout the season. The rape can be planted with the corn and the corn hogged off.

Skoglund Farm.

[Statement by W. S. Skoglund, figs. 31, 32, and 33.]

This farm is a square quarter section of nearly level land in southwestern Minnesota. Nearly all of the farm is tillable. New buildings are just being put up, as the farm is comparatively new.

Diversified farming is carried on, considerable attention being given to dairying. The live stock consists of 15 cows, 5 horses, 100 chickens, 30 turkeys, 10 hogs, and 20 head of young stock.

No rotation has been followed, but the fields were laid out last year for a 4-year rotation as shown in figure 32.

THE NEW PLAN.

The 4-year rotation gives more grass than needed, so I have changed it to a 5-year rotation, as follows: First year, corn; second year, oats; third and fourth years, grass; fifth year, wheat. One eighty is divided into 3 equal fields and the other into 2 equal fields after deducting 20 acres for farmstead and minor rotation. Ten acres were divided into three equal parts for a minor rotation of: First year, peas and oats; second year, roots; third year, fodder corn.

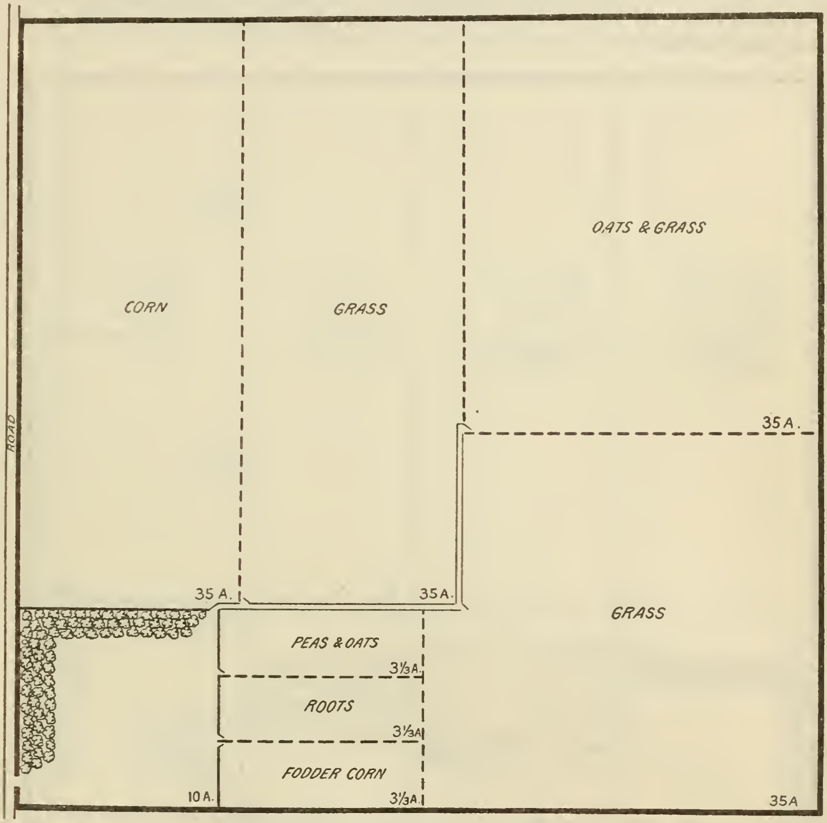

FIG. 31.—Skoglund Farm. Original plan.

INSTRUCTOR'S CRITICISM.

Your change from a 4 to a 5 year rotation is wise, and one of these fields in pasture, with catch pasture crops, such as rape, sowed in the corn and oats, will now furnish you ample pasturage. The arrangement of fields, however, is not as good as you might make. Would suggest dividing fields C and D the other way, as shown in figure 33. This would require a little less lane to reach C and would make the fields more convenient to manure, giving longer bouts with the plow. Would suggest that the oats and wheat be transposed in the rotation, as wheat is a better nurse crop than is oats.

The crops which you propose to grow in the minor rotation are not well chosen. It is impracticable to invest $100 in labor and other expenses to grow 3 acres of roots. Half that expense will furnish a good supply of succulent feed and make as much work as you will care to devote to these fields. Would suggest that you add another small field, as shown in figure 33, and make your rotation: First year, oats and peas, followed by rye; second year, corn; third year, grain; fourth year, clover. The clover will furnish pasturage for the hogs much more cheaply than will annual crops, as the cost of production is very much less and the effect on the soil is much better.

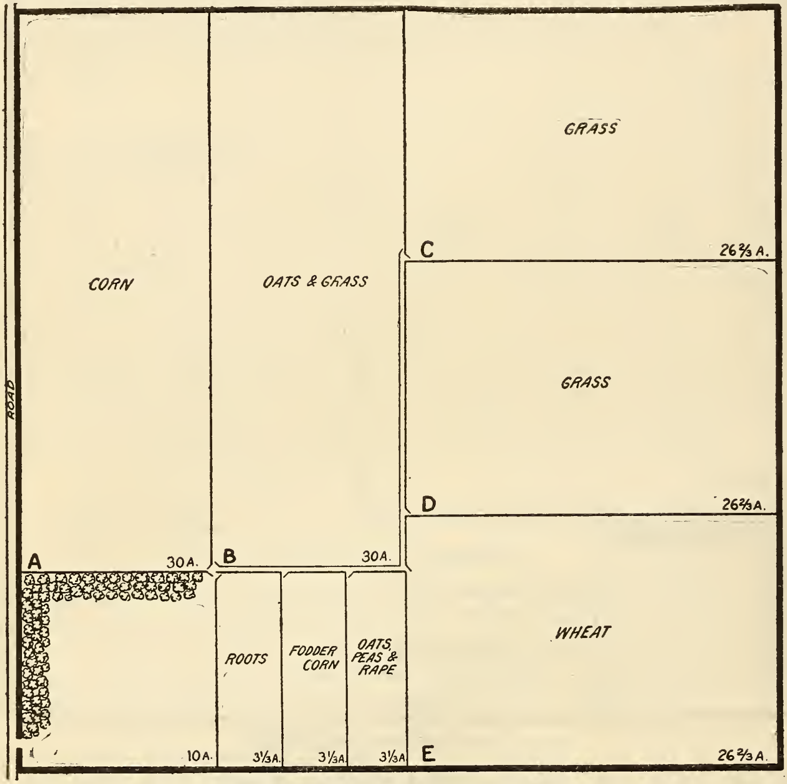

FIG. 32.—Skoglund Farm. Student's plan.

LAKE VIEW FARM.

[Statement by Theodore J. Sampson, fig. 34.]

Lake View Farm is situated in the central part of Meeker County, in Greenleaf Township, on the Great Northern road, 2 miles northeast of Star Lake creamery and Strout post office. The soil is mostly a light clay, except on some of the hills where there are spots of yellow clay mixed with stones. The farm comprises 280 acres. It contains 60 acres of forest, 5 acres of water, and 37 acres of low meadow land; 168 acres are under cultivation, while 10 acres are devoted to farmstead and garden. General farming is practiced, with special attention to dairying. Wheat, flax, mature dairy cows, calves, and hogs will be the principal products marketed. The stock kept is nearly as follows: 20 mature cattle, 5 two-year-old heifers, 10 yearlings, 12 calves, 6 hogs, 25 pigs, 6 work horses, and 50 chickens.

A public road runs along the east and south sides of the northwest forty, then turns south, following the west boundary line. A private road runs through the center of the farm and through the farmstead. Permanent lanes run east and west, connecting the fields with the farmstead, as shown in figure 34.

THE STUDENT'S PLAN.

Rotation: The cultivated portion of the farm is divided up into two series of rotation fields. One consists of 8 fields of 16 acres each, A, B, C, D, E, F, G, and H, and the other of 5 fields of 8 acres each, I, J, K, L, and M. The succession of crops on each field is figured out and shown on the plat. The permanent meadow will not come under any rotation, but will be kept for hay only, and will be fertilized with such well-rotted manure as can be spared from the rotation fields. The rotations have been decided upon in a general way and may be modified slightly as necessity requires. To the rotation for the large fields may be added rape after wheat for fall pasture. In the rotation on the small fields, where corn is named, part may be planted to potatoes and part to corn fodder; and in the fields where small grains are placed, any grain for sale or feed may be placed.

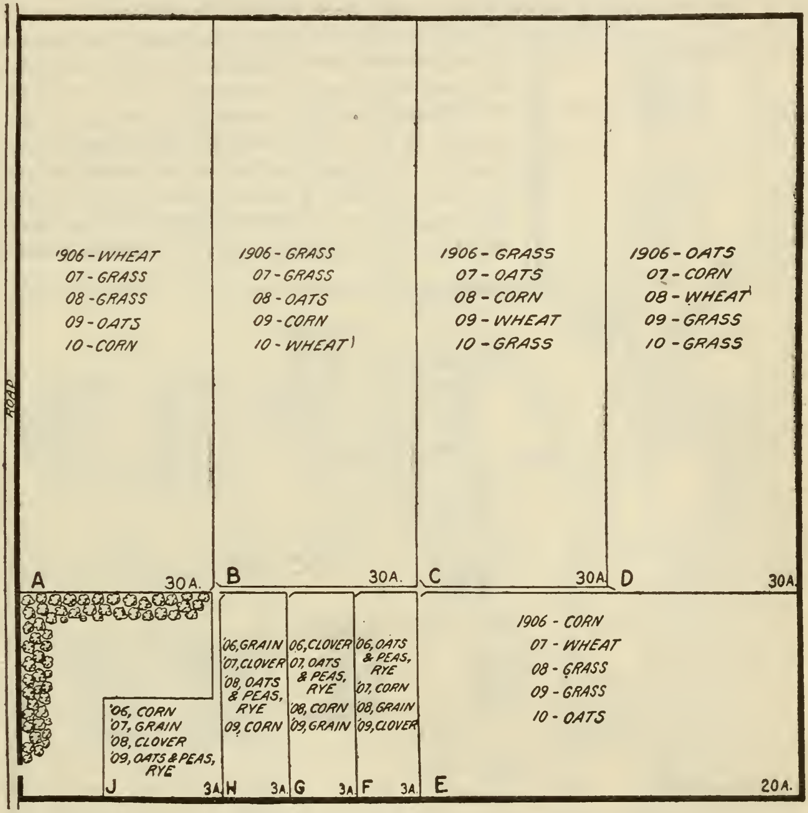

FIG. 33.—Skoglund Farm. Revised plan.

Permanent fences are maintained around most of the outside lines, along lanes, and around permanent pastures. The rotations are so arranged that, in some cases, temporary fences, located two years in one place, serve nearly all needs. Fields A and

C being far from the farmstead can be used for meadow three years, and fields B and D can be pastured two years each, instead of one, as indicated, thus avoiding so much change in fencing and at the same time not disturbing the rotation in the least.

A large open ditch with its branches running through the lowland on the west half of the farm drains southwest to Evenson Lake. A ditch on the east side drains the east meadow. Low places in the fields are drained off by slough ditches which can be cultivated across. It is impracticable to drain the small marsh in field D.

INSTRUCTOR'S CRITICISM.

This plan shows a good example of an 8-year rotation where flax fits in well. With 8 years intervening between flax crops there is little danger from losses on account of flax wilt where reasonable care is taken to secure seed free from flax-wilt spores and to treat the seed with formalin solution.

In localities where it is difficult to get a stand of grass in droughty years this longer rotation can easily be temporarily moved so as to adapt itself to a loss of a year's failure to get a catch of grass. For example, if on field C in 1905 the grass stand should not be sufficiently heavy to warrant it being allowed to remain, it could be plowed up and seeded to flax and the pasture on field G allowed to lie during 1905 and then be plowed up and seeded to wheat, its regular crop, in 1906. In field C the grass could be seeded with the flax, though this is not as good a nurse crop as wheat, and be allowed to lie 2 years in grass instead of 3 years. This plan would give flax again in 1908 on field C, but where the land is kept in such condition as this will be by such rotation, and since seed can be treated with formalin, there is no objection to such an occasional change.

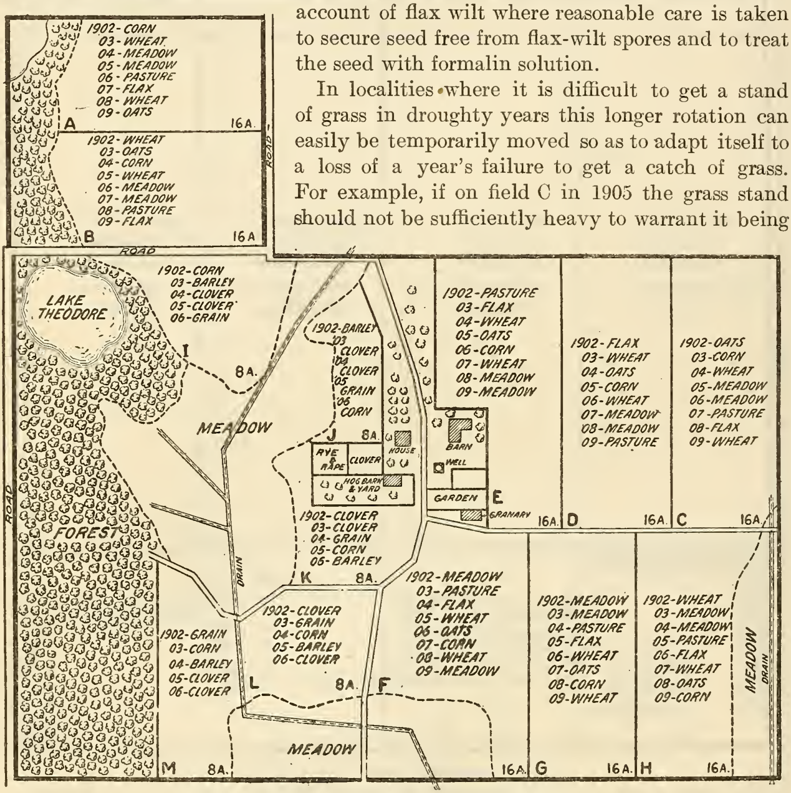

FIG. 34.—Lake View Farm. Reorganized plan.

The forest contains a great deal of pasture land, which evidently accounts for the small number of acres in rotation grass. Since clover is not likely to live over 2 years in succession, it will be better to sow timothy with the clover when hay or pasture is desired in the 4-year rotation. In case the clover fails, an additional grain crop may be grown in one of these 8-acre fields.

MARPLE FARM.

[Statement by E. E. Marple, figs. 35 and 36.]

Marple Farm consists of 320 acres located near Wendell in Grant County, Minn. The public road running east and west cuts off the south 80 and another road running north and south cuts off the east 80 from the 160 on which the farmstead is located. The three forties, extending three-fourths of a mile to the southward from the farmstead, are mostly taken up with a big dry meadow which has never been broken up. However, the land is all tillable excepting a 5-acre strip on the south end of the east 80. I expect to keep on the farm 50 head of cattle, 10 horses, 50 sheep, 4 sows, and 200 chickens. The farm is fairly well equipped with buildings, consisting of a house, woodshed, barn, granary, hog house, and feed house. Until a few years ago nothing was raised except grain, but of late years about a carload of cattle are fed each year, and about 50 head of sheep and a few hogs are kept.

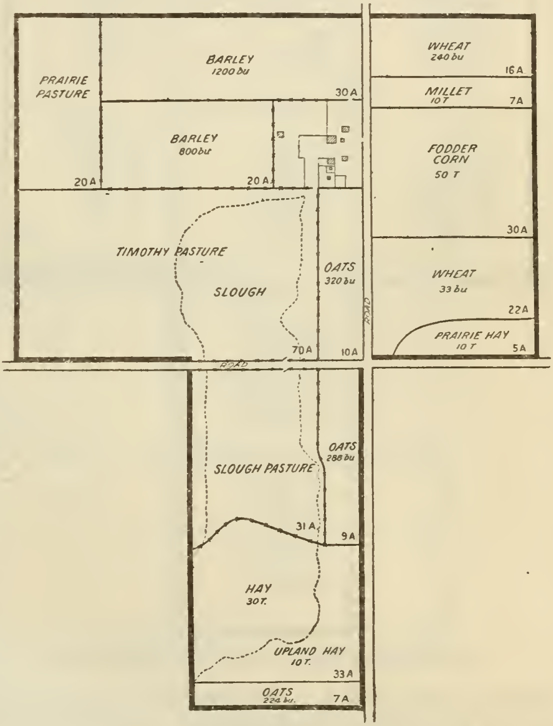

FIG. 35.—Marple Farm. Original plan.

THE NEW PLAN.

No rotation has ever been thought of, but I have planned a 7-year rotation to be in working order in 1906 (fig. 36). A year or two will be required in which to break up the old meadows and get grass sown in the right fields. The fields will be 40 acres each and will be rotated as follows: First year, corn; second year, wheat; third, fourth, and fifth years, grass; sixth year, barley; seventh year, oats. Forty acres will be set aside for the farmstead and for a 3-field rotation which is divided as follows: Ten acres for farmstead, and 3 fields of 10 acres each in which the 3-year rotation will be: First year, grain; second year, grass; third year, corn and roots.

INSTRUCTOR'S CRITICISM.

Flax will often be more profitable than barley following the 3 years in grass. In case it is inconvenient to get stock to the two 40-acre fields on the south you might pasture them all the time on the farther fields and use all grass on these south fields for hay. Since you have a large farm and presumably use 4-horse machines, it might pay to divide fields D and E and also fields B and C in the other direction, giving longer rounds and somewhat reducing the distance from the farmstead to the fields. In the minor rotation you doubtless mean clover when you say grass. It may pay you to replace the fodder corn and roots with ear corn and rape in this 3-field rotation. You can grow the roots and fodder corn needed in your large rotation so as to hog down the corn and rape in the 10-acre field. As your farm develops in productivity under this rotation scheme you will find that you can keep more live stock, and I suggest that in that case there be a larger number of hogs.

Greaves Farm.

[Statement by H. A. Greaves, figs. 37, 38, and 39.]

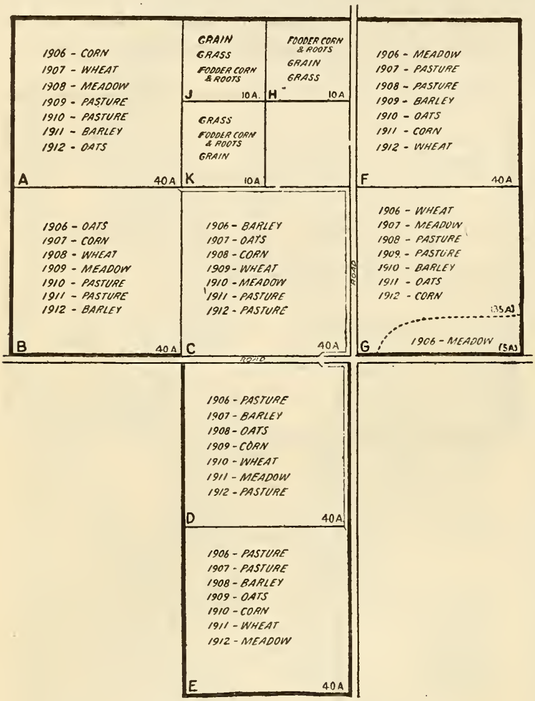

FIG. 36.—Marple Farm. Key map to student's plan.

This is a 160-acre farm situated 3 miles north of Northfield, Rice County, Minn. The public road runs through the farm east and west cutting off the south 40, as shown in figure 37. The land is all tillable excepting a small piece in the corner of one of the fields. The buildings consist of a good house, barn, granary, and hog house. Dairying is the line of farming followed, all the farm produce being fed on the farm excepting 200 bushels of oats, which amount is usually sold and the proceeds used to buy cheaper mill stuffs. The stock kept is 30 head of dairy cows, 7 horses, and 4 hogs.

THE NEW PLAN.

No rotation has ever been followed, but there is no good reason why one should not be established, and by seeding the 16 acres south of the road to grass in the spring, the 7-year rotation given in figure 38 can immediately be taken up. The 7 fields will be 20 acres each, and all are arranged with a view to being reached easily from the farmstead. The rotation consists of: First year, corn; second year, barley; third, fourth, and fifth years, grass; sixth year, fodder corn; seventh year, oats.

A 4-field rotation is placed on the 10-acre plat west of the farmstead and consists of a rotation as follows: First year, millet; second year, sorghum; third year, roots; and fourth year, sweet corn.

Figure 39 shows the use of a blank map as a ledger sheet.

INSTRUCTOR'S CRITICISM.

The plan suggested is feasible and with a few changes should give good results. Your statement of getting the 16 acres of corn stubble, south of the road, seeded is a little indefinite. However, this can be managed by pasturing as much of the seeded grass land south of the road as needed in 1903; then cut the rest for hay, sow the corn stubble to grain and seed down in 1904; then grow enough fodder corn on some other part of the farm to supply the needed roughage. Thus in 1905 the rotation can be run regularly as planned.

The arrangement of your pasture and meadow should be changed so that the first-year crop is cut for grass, pasturing the second and third years after the grass is better rooted. A little alsike clover seeded with the timothy and red clover will help out the pasture the second and third years. In figure 38 the word "manure" in parenthesis should be before the word "corn" rather than after the word "oats."

If the lay of the land allows, your plan can be somewhat improved by dividing fields A and C so as to run north and south, having each of these two fields join the farmstead, thus making but 40 rods of travel necessary to get to field A.

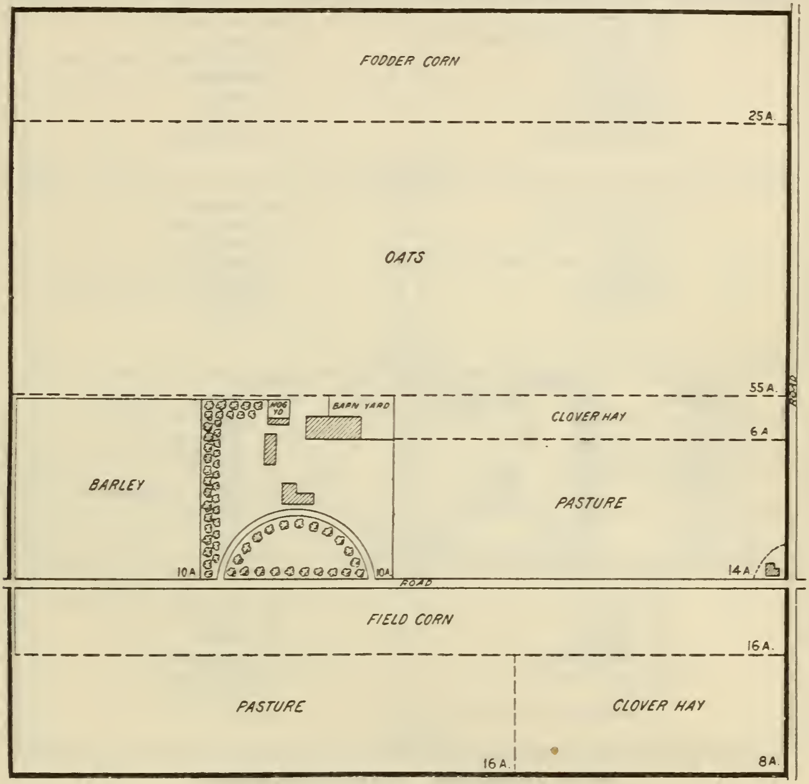

FIG. 37.—Greaves Farm. Original plan.

The arrangement of fields for the 4-year rotation is good but the rotation is poor. You are raising all exhaustive crops. The following rotation would be better: First year, sweet corn; second year, grain; third year, clover; fourth year, potatoes and roots.

Besides the 30 dairy cows you could very profitably keep a larger number of hogs, which this 4-field rotation would provide with pasturage. By providing acreage for roots and potatoes on the farmstead you could have corn grown for ears sowed in with rape on two of the small fields, which could then be hogged off.

AUSTVOLD FARM.

[Statement by Mr. Austvold, fig. 40.]

This farm is located in the central part of Pope County, Minn., about 4 miles east of Lake Minnewaska on the southern border line of the town of Glenwood. It contains 560 acres of prairie land, besides having an addition of 80 acres of timber and meadow land which is located about 1½ miles west.

THE NEW PLAN.

To carry out the rotation outlined in the accompanying plan, I intend to have about 80 head of mature cattle, possibly more; no sheep, but possibly a few hogs. Fields in grain and not seeded to grass will be sowed in with rape for fall pasture. Intend to keep about 12 working horses and 2 hired men the year round. The cattle will be grade Shorthorns.

There are 3 sets of rotations to be carried out as shown on the plan. The five fields, A, B, C, D, and E, each containing about 80 acres, will be rotated as follows: First year, wheat; second year, clover and timothy meadow; third year, pasture; fourth year, oats and flax; fifth year, corn and fodder corn. The stubble in the field following oats and flax is to be manured for the next corn crop.

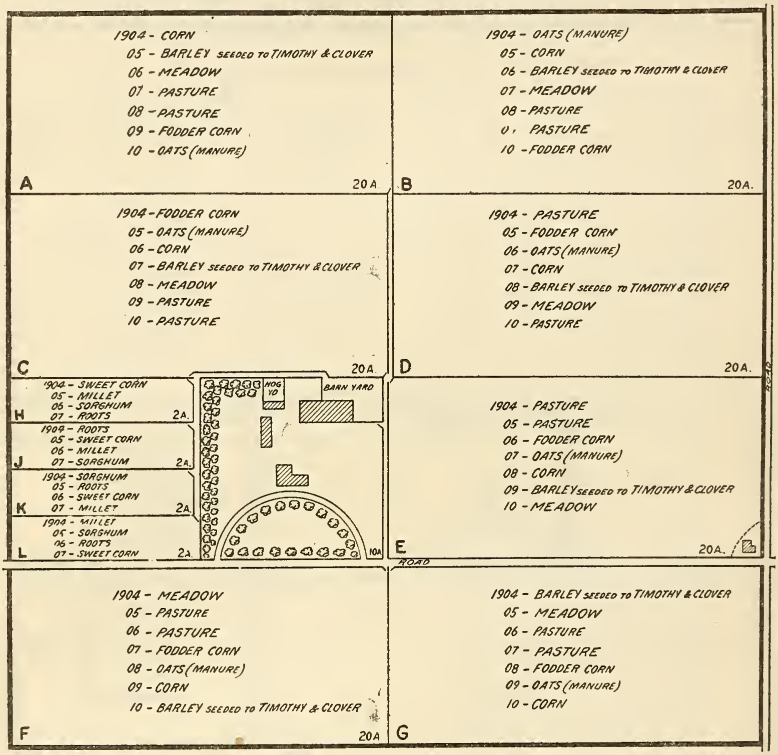

FIG. 38.—Greaves Farm. Key map to student's plan.

The 5 fields, F, G, H, I, and K, containing about 10 acres each, will be cropped in a 5-year rotation as follows: First year, wheat; second and third years, clover and timothy; fourth year, fodder corn; fifth year, fodder corn. The fodder corn on these fields is intended to be fed out to the cattle as a soiling crop and in this way help out the pastures in midsummer. The manure will be applied before the corn crop. Fields L and M will be rotated with roots one year; barley or some other grain the next year. O is intended for a permanent horse pasture.

INSTRUCTOR'S CRITICISM.

This is a good example of careful planning for a farm of this size. But few lanes are provided and yet every field can be most conveniently reached, though the farmstead is far removed from the highway. By fencing this farm and sowing rape with the grain crops that follow grass, much pasturage is provided on the 80-acre fields. The grass the second year would be pastured in most cases. Thus in 1903 field C would be in pasture and in the fall field D would be in rape. By opening a gate in the southeast corner of field K 160 acres of fields C and D are in one field for fall pasture and are connected by a lane with the farmstead. In 1905 the pasturage will be in field A and rape will be in field B. In 1906 the rape and grass pasture will be in separated fields; that is, grass in field E and rape in field A. Again, in 1907, pasture is in field D and rape in field E. Doubtless many low areas about the lakes can be profitably drained.

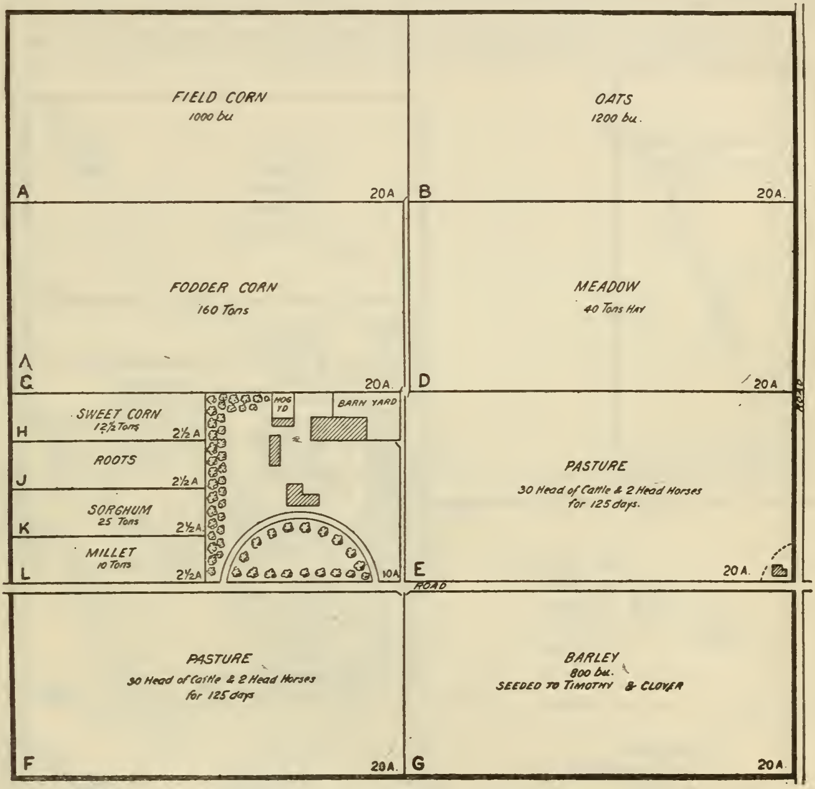

FIG. 39.—Greaves Farm. Key map to revised plan.

ANTHONY FARM.

[Statement by H. H. Mowry, figs. 41, 42, and 43.]

THE STUDENT'S PLAN.

This is a 160-acre farm in the Red River Valley and was arranged in 1902, as shown in figure 43. The permanent pasture in the southwest corner, as well as the outside boundaries of the entire farm, was fenced prior to 1902, as shown in figure 41. The main crop on this farm has been wheat. In the northeast corner, where it was summer-fallowed in 1902, considerable wild oats had gotten in and there are patches of it over the entire farm. In selecting a rotation the problem of checking this weed in particular received consideration, and as the general experience in that country indicates that this can best be done by growing hay and pasture crops, and as it is sometimes difficult to get a stand of grass, an eight-year rotation was chosen in which three years of grass are followed by corn. In the minor four-year rotation the same idea of combating wild oats was kept in view. In the major rotation a flax crop instead of corn might be profitably raised after the grass crops, provided the land was clean.

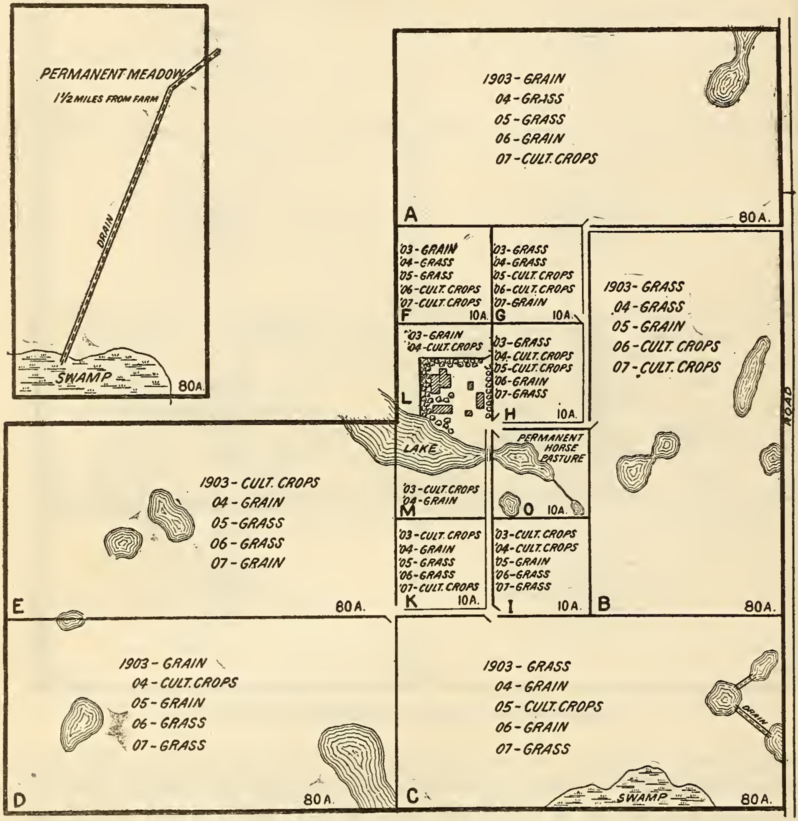

FIG. 40.—Austvold Farm. Key map to student's plan.

The major rotation occupies eight 15-acre fields, A, B, C, D, E, F, G, and H, arranged as shown in figure 42, while the minor rotation occupies the four smaller fields, I, J, K, and L, containing about 6 acres each. The crops for 1903, not indicated in the rotation plan, which are used in the transition to the permanent rotation schemes, are as follows: Corn to be put on E to check the wild oats. Fields A, C, and G are to be put into grass for pasture and to check wild oats. Field K in the former permanent pasture will be plowed up and put into flax. After that the rotation outlined in figure 42 will obtain.

A lane will be run along the south ends of A, B, and C, from which E also can be reached. The other fields can be reached without additional lanes, except a short piece on the west end of G, by passing through permanent pasture along the coulee.

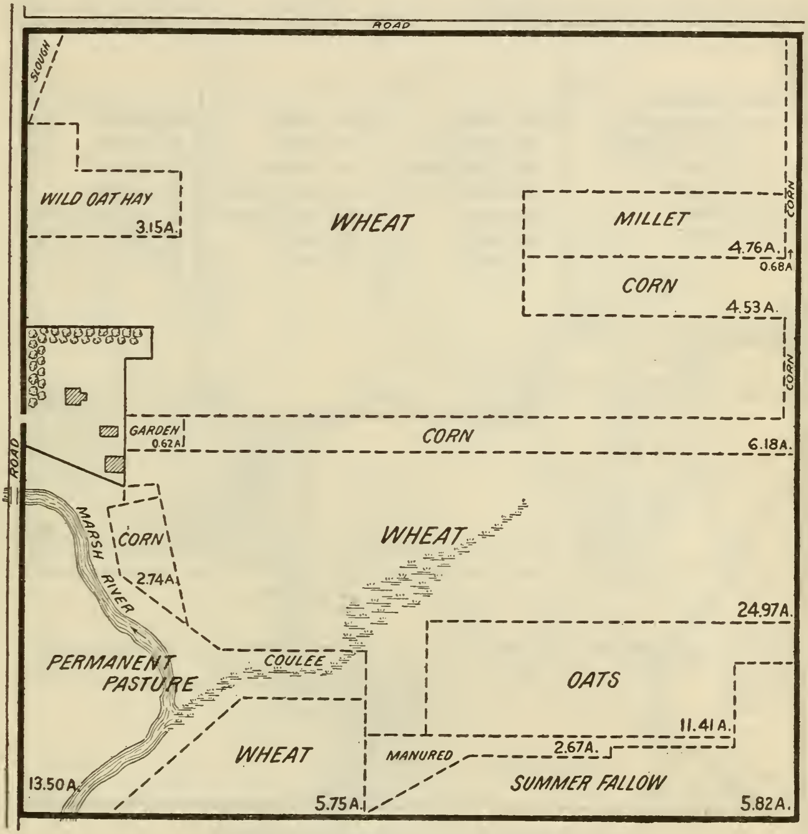

FIG. 41.—Anthony Farm. Original plan.

The intention is to keep about 15 cows, with some young stock, also 5 head of horses and 150 chickens.

INSTRUCTOR'S CRITICISM.

It will be observed from the above description and from figure 42 that there would be annually 60 acres of small grain, 45 acres grass and hay, and 15 acres of corn. While this may be a suitable rotation for that locality, it would seem that nearly the same amount of grass and grain could be raised in a 7-year rotation on seven 18-acre fields, and this would be more economical, as it would save 1 fence and make 2 less fields on the farm, and besides the fields would be a little larger. Discussing such a change illustrates the fact that a farm can be cut up in many different ways to suit conditions and crop requirements. For example, suppose this farm is divided into 10 fields instead of 12, as in figure 43, giving a 7-year rotation on 7 fields, each 18 acres in size. First year, corn; second year, wheat; third, fourth, and fifth years, grass; sixth and seventh, corn with rape. Then on the 3 small fields you could have either a 6-year or two 3-year rotations, or a 3-year rotation, as follows: First year, corn; second year, wheat; third year, clover. Since, however, clover often fails in this part of the State, a double-crop rotation could be used on these 3 fields, thus: First and second years, corn; third and fourth years, grain; fifth and sixth years, clover and timothy. This would give 1 crop of corn, 1 of wheat, and 1 of grass in each of the small fields each year, while the timothy sown with the clover would nearly always give pasture or hay.

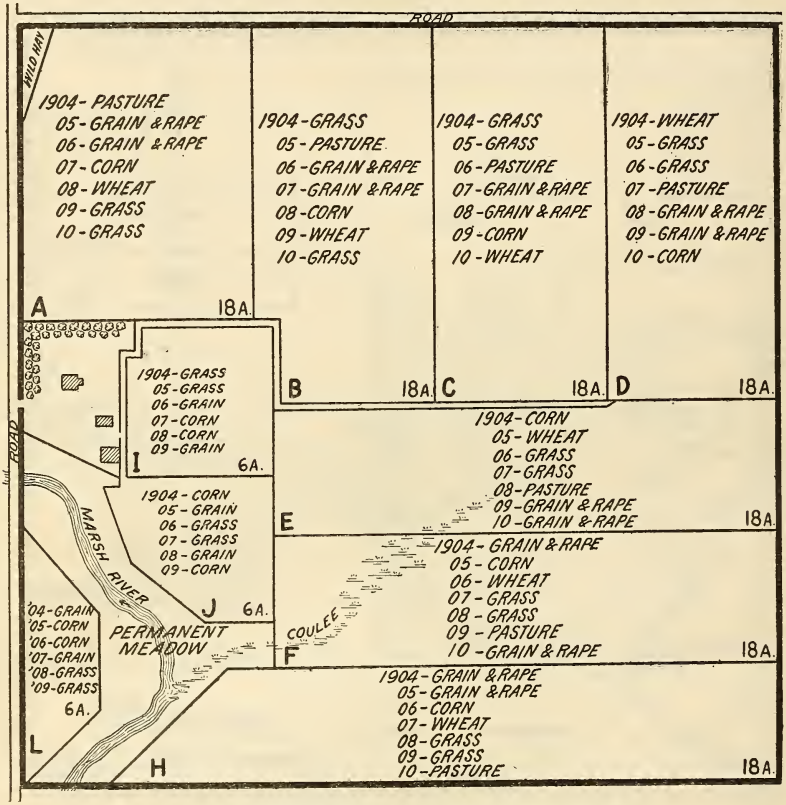

FIG. 42.—Anthony Farm. Key map to student's plan.

Still a better plan for the 3 fields would be to inaugurate a 6-year rotation as follows: First year, corn; second year, grain; third and fourth years, grass; fifth year, grain; sixth year, corn. This gives a crop of grain, a crop of corn, and a crop of grass each year, keeps the grass seeded 2 years, and supplies the 2 grain crops.

WHITNEY FARM.

[Figs. 44, 45, and 46.]

This farm is located 30 miles north of Minneapolis, between Anoka and St. Francis. The Rum River runs through the southeast corner, cutting off 5 acres, which are used for permanent pasture. General farming is carried on, corn, oats, wheat, and hay being the chief crops grown. The live stock kept is about 40 cattle, 50 hogs, and 6

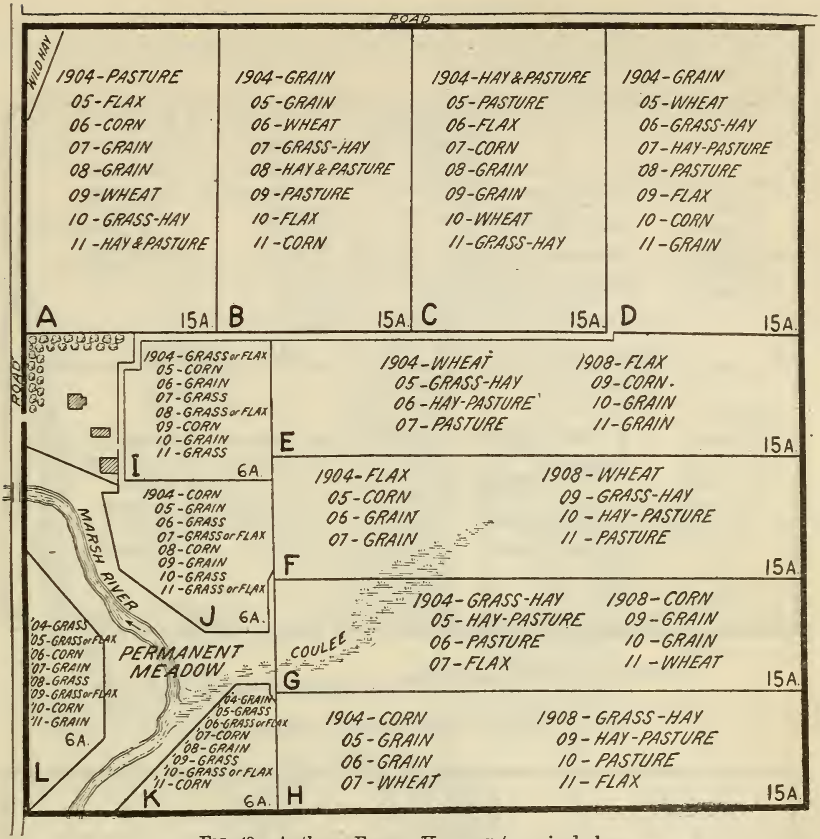

FIG. 43.—Anthony Farm. Key map to revised plan.

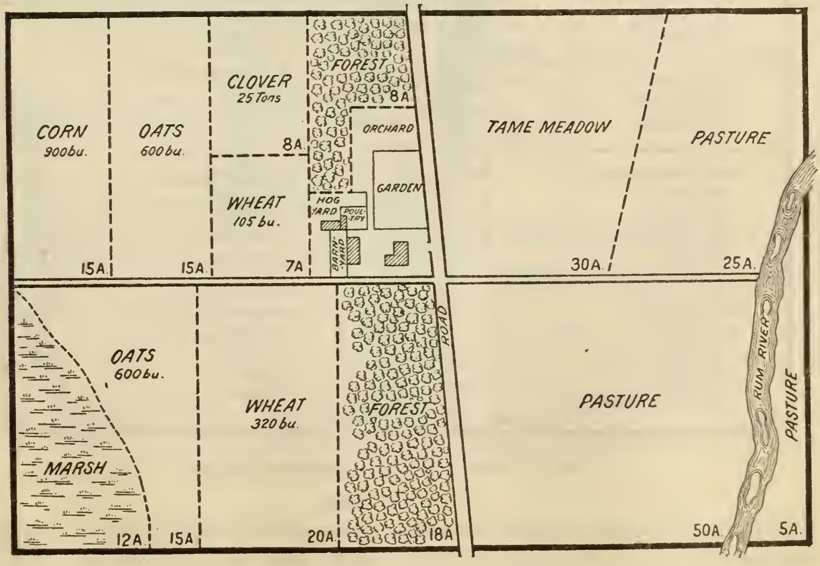

FIG. 44.—Whitney Farm. Original plan.

horses. About a dozen fat steers are marketed each year. No systematic rotation has been followed, about half of the farm being devoted to grain and cultivated crops and the other half to hay and pasture.

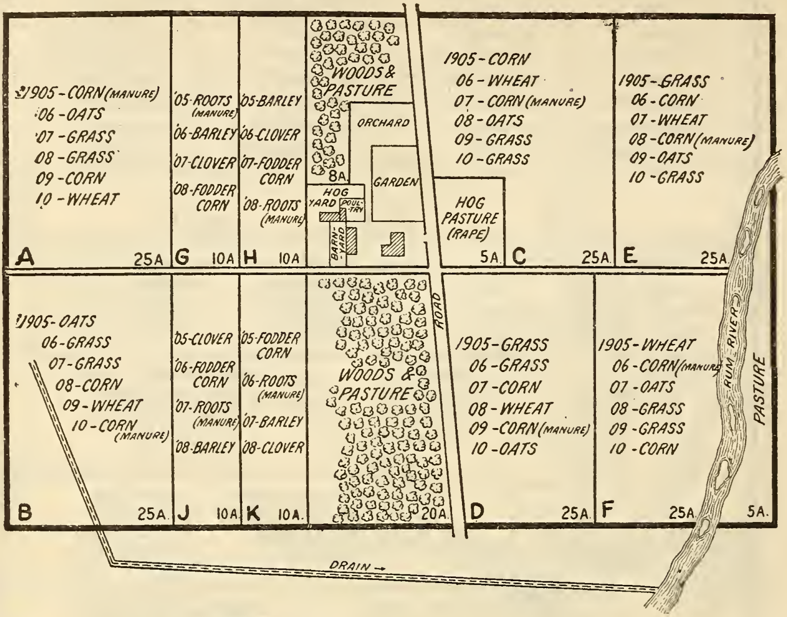

FIG. 45.—Whitney Farm. Key map to student's plan.

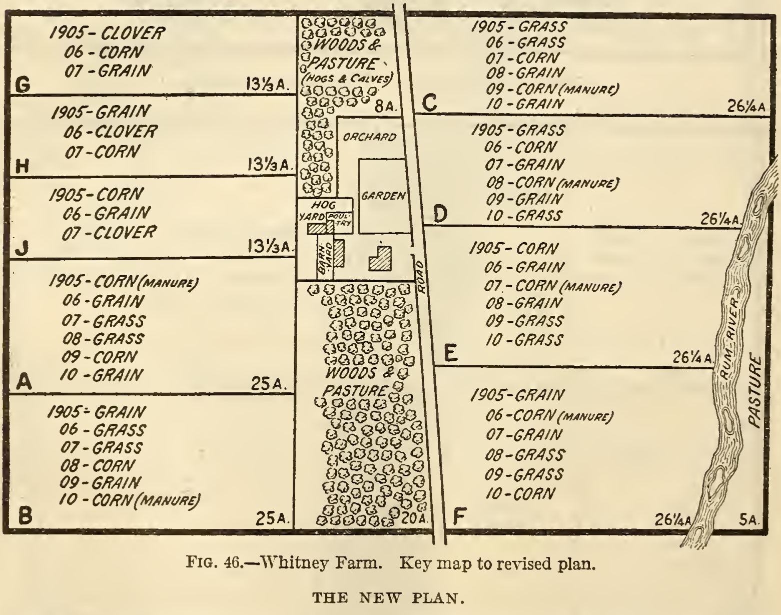

FIG. 46.—Whitney Farm. Key map to revised plan.

THE NEW PLAN.

In figure 45 is shown a plan under which the crops are brought under a systematic rotation in the year 1905, with one 6-field rotation and one 4-field rotation. On the

6 fields of 25 acres each the rotation is as follows: First year, corn; second year, wheat; third year, grass; fourth year, oats; fifth and sixth years, grass. On the four 10-acre fields the rotation is: First year, root crops; second year, barley; third year, clover; fourth year, fodder corn. Ten acres are in the farmstead, 26 acres in woodland, and 5 acres are set aside for a hog pasture. The main road runs through the farm nearly north and south and a lane is planned to cut the farm at nearly right angles to the road that free access may be had to the fields and to the river.

INSTRUCTOR'S CRITICISM.

The 6-year rotation is good except that it might be better to change the terms wheat and oats to grain, which makes the rotation statement more flexible, allowing the use of any grain, as wheat, oats, barley, or flax. The amount of pasture is rather short for the amount of stock kept, but by making use of catch crops in stubble fields, as turnips in flax, rape in wheat and corn, and by pasturing the aftermath in hay and grain fields, sufficient pasturage will be supplied. However, the arrangement of the fields might possibly be improved as in figure 46. Here all fields east of the road may be reached from the public highway. West of the road the fields are turned so that they are reached from the woods pasture, thus avoiding the need of a lane. The 40 acres for a minor rotation is changed to three 13-acre fields, connecting with the north woods pasture, with a rotation as follows: First year, corn; second year, grain; third year, clover. This woods pasture seeded to white clover, alsike clover, Kentucky bluegrass, and timothy will furnish much pasture for hogs and calves, and whatever more can be used to advantage by these animals may be fenced off from one of the 3-year rotation fields. If desired, a part or all of the corn in this rotation could also be conveniently hogged off.

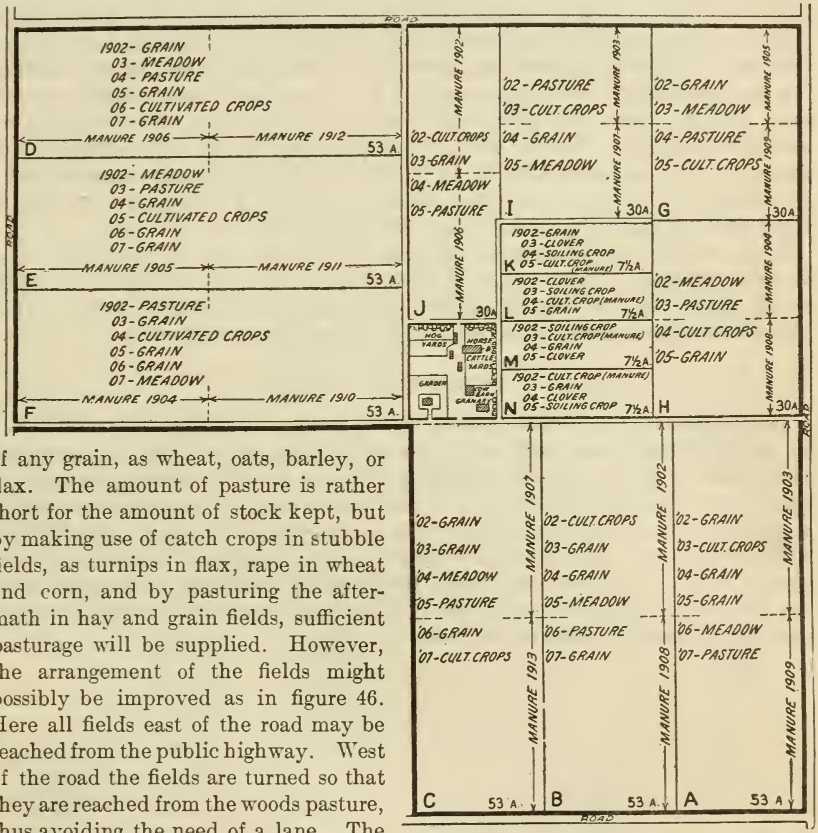

FIG. 47.—Anderson Farm. Key map to student's plan.

ANDERSON FARM.

[Statement of Julius Anderson, fig. 47.]

This farm is situated in Renville County, Minn., in the town of Melville, in section No. 5, about 4 miles northeast from Bird Island. The farm contains 480 acres, of which 10 acres is farmstead, while the fields are to be divided into a system of 3 rotations: First, six 53-acre fields, A, B, C, D, E, and F; second, four 30-acre fields, G, H, I, J; third, four 7-acre fields, K, L, M, and N.

THE STUDENT'S PLAN.

I intend to keep 12 working horses, 70 cattle, and 100 hogs. The horses will be kept in the barn most of the time and will be fed on hay and oats with a small amount of corn. The cattle will be fed on grain, hay, and fodder corn in winter, and in summer they will be kept in the rotation pasture for 4 months and 1 to 2 months on annual pastures, especially rape sown among the grain crops on fields on which no grass is sown with the grain. For grain feed I will use barley, bran, and corn, with some roots and roughage. The pigs and calves will be kept on the field containing clover pasture in the rotation in fields K, L, M, N in the spring and in the summer and fall in the field containing oats and peas, followed by rape. If necessary, I can put rape along with the grain crop in this rotation for fall pasture.

There will be sown 143 acres of wheat, all of which will be sold except that needed for flour and seed. There will be about 60 acres of corn, most of which will be used for the hogs. The 33 acres of oats will nearly all be used for the horses. The 20 acres of barley will nearly all be fed to the pigs and cows with some for the horses.

INSTRUCTOR'S CRITICISM.

The student says that when desired he can sow rape with the oats in fields K, L, M, and N. Since clover will have been seeded with the oats this is impracticable as the shade of the rape and the trampling of the stock while pasturing the rape would destroy the stand of clover designed for next year's crop. The student having failed to place all the rotation statements in their proper sequence in their respective fields, Table XV serves to enable both the student and the instructor to check up the crops in each field for each year and also to show how two crops may be grown in some of the fields and to state other facts both in projecting a plan and in writing the history of what was actually grown on the farm.

TABLE XV.—*Sequence of rotations on the Anderson Farm.*

SIX-FIELD ROTATION.

	1902		1903		1904		1905		1906		1907	
Field.	Crop.	Acres.	Crop.	Acres.	Crop.	Acres.	Crop.	Acres.	Crop.	Acres.	Crop.	Acres.
A..	Wheat....	53	Corn......	53	Oats....... Barley....	33 20	Wheat....	53	Grass.....	53	Pasture, 45 cattle, 4 months.	53
B..	Corn......	53	Oats....... Barley....	33 20	Wheat....	53	Grass.....	53	Pasture...	53	Wheat....	53
C..	Oats....... Barley....	33 20	Wheat....	53	Grass.....	53	Pasture...	53	Wheat....	53	Corn......	53
D..	Wheat....	53	Grass.....	53	Pasture...	53	Wheat....	53	Corn......	53	Oats....... Barley....	33 20
E..	Grass.....	53	Pasture...	53	Wheat....	53	Corn......	53	Oats....... Barley....	33 20	Wheat....	53
F..	Pasture...	53	Wheat....	53	Corn......	53	Oats....... Barley....	33 20	Wheat....	53	Grass.....	53

FOUR-FIELD, 30-ACRE ROTATION.

G..	Wheat....	30	Grass.....	30	Pasture, 25 cattle, 4 months.	30	Fodder, corn. Roots..... Beans..... Potatoes..	20 6 3 1	Wheat....	30	Meadow...	30
H..	Meadow...	30	Pasture, 25 cattle, 4 months.	30	Fodder, corn. Roots..... Beans..... Potatoes..	20 6 3 1	Wheat....	30	Meadow...	30	Pasture, 25 cattle, 4 months.	30
I...	Pasture, 25 cattle, 4 months.	30	Fodder, corn. Roots..... Beans..... Potatoes..	20 6 3 1	Wheat....	30	Grass.....	30	Pasture, 25 cattle, 4 months.	30	Fodder, corn. Roots..... Beans..... Potatoes..	20 6 3 1
J...	Fodder, corn. Roots..... Beans..... Potatoes..	20 6 3 1	Wheat....	30	Grass.....	30	Pasture, 25 cattle, 4 months.	30	Fodder, corn. Roots..... Beans..... Potatoes..	20 6 3 1	Wheat....	30

FOUR-FIELD, 7-ACRE ROTATION.

K..	Wheat....	7	Clover pasture for 100 pigs and 20 spring calves for 2½ months.	7	Oats, peas, rape, for pasturing 100 pigs and 20 calves the next 2½ mo's.	7	Corn......	7	Wheat....	7	Clover pasture for 100 pigs and 20 calves for 2½ months.	7
L..	Clover pasture, as above.	7	Oats, peas, rape, as above.	7	Corn......	7	Wheat....	7	Clover pasture, as above.	7	Oats, peas, rape, as above.	7
M..	Oats, peas, rape, as above.	7	Corn......	7	Wheat....	7	Clover pasture, as above.	7	Oats, peas, rape, as above.	7	Corn......	7
N..	Corn......	7	Wheat....	7	Clover pasture, as above.	7	Oats, peas, rape, as above.	7	Corn......	7	Wheat....	7

HATHAWAY FARM.

[Statement by F. C. Hathaway, figs. 48 and 49.]

This is a square 160-acre farm situated north of Winnebago City, in Blue Earth County, Minn. The fields are badly cut up at present by a number of sloughs, making the farm quite wet, but all these can be drained easily and this will be done soon. It has fair buildings, consisting of a house, barn, and granary.

A strictly grain line of farming has been carried on here for 30 years and the land is badly run down, but was bought with the intention of making it a stock farm. By judicious handling we expect soon to get good results from our work in the way of animal products. It is planned to keep 4 horses, 5 cows, 12 steers, and 40 to 50 hogs, and also to feed a large number of sheep in the fall on rape and other autumn pastures.

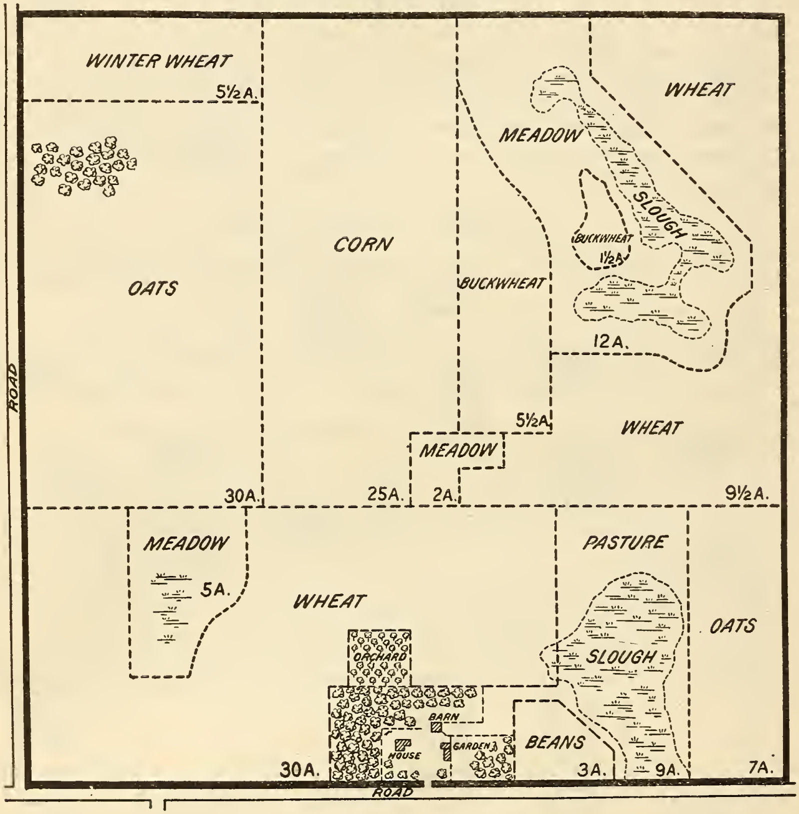

FIG. 48.—Hathaway Farm. Original plan.

THE NEW PLAN.

In order to get the farm into any kind of a rotation it will first be necessary to drain the sloughs. It will also require 2 or 3 years' preparation, so that the old meadows may be broken up ready for cropping and new meadows and pastures seeded for the starting of the rotation. The little patch of woods in the northwest corner will be cleared up, that we may have good regular fields.

The rotation as completed for 1906 is a 5-year rotation, each field to be 20 acres in size. The northeast field, in which the big slough was, is to be seeded to brome and other grasses for permanent pasture, hence will not be considered in the rotation, which is: First year, corn; second year, oats; third year, corn; fourth year, barley, fifth year, clover. The 6 smaller fields accommodate two 3-year rotations, one on each side of the farmstead, and are designed simply for temporary hog and sheep pastures during the summer months. One rotation is: First and second years, grain; third year, clover; and the other is: First year, grain; second year, clover; third year, garden. The fields are all arranged for greatest convenience, as I see it.

INSTRUCTOR'S CRITICISM.

The general plan you have adopted is very good and if, as you suggest, enough live stock is kept to utilize all of the feed the farm will produce, you should be able with this rotation to build up the productivity of the soil sufficiently within a few years to insure profitable yields. The terms barley and oats should be changed to the more general term, grain, as this gives a little more flexibility to the rotation without in any way impairing its value.

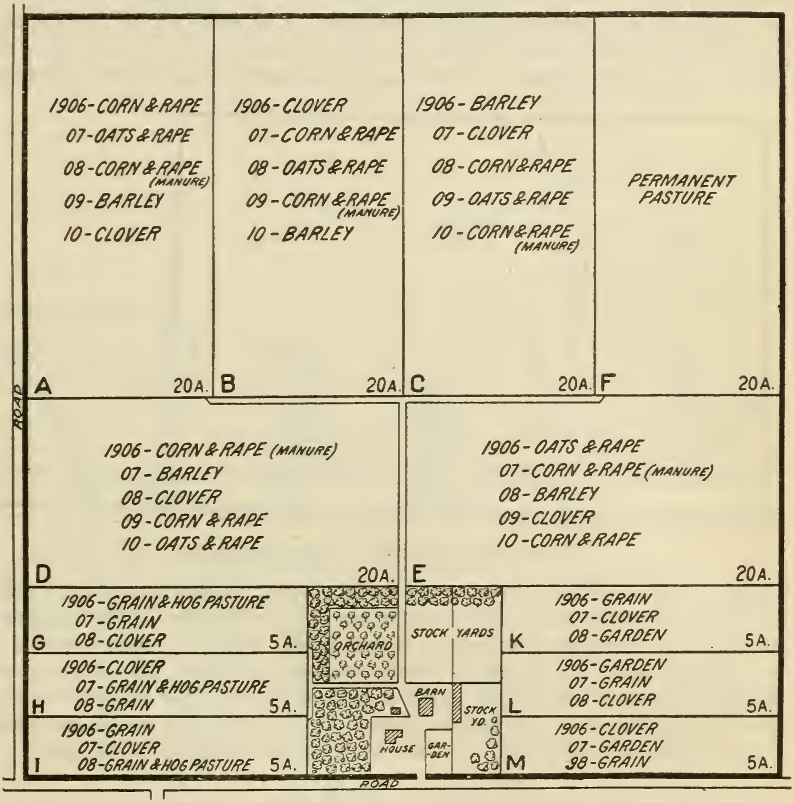

FIG. 49.—Hathaway Farm. Key map to student's plan.

It will pay you to invest up to $20 to $50 per acre to drain the permanent pasture so that this field may also be tillable, for another year of grass and the effect of pasturing will be valuable to the other fields. This would allow you a 6-year rotation with 2 years of grass in place of 1 as you now have it. This would undoubtedly increase the average yields of all crops other than grass, and the rotation pastures would doubtless yield more than permanent pasture as on field F. Were you to invest $400 in draining that 20 acres and the drain were properly and carefuly laid you would then have a permanent improvement, increasing by much more than that sum the value of your farm. The annual charge against this improvement would be only interest on the investment, which at 6 per cent would be $24. If the change of rotation made possible by this drainage would result in an increased yield of 24 cents per acre per year on each of the other five 20-acre fields, the investment would be warranted, to say nothing of the improvement on the 20 acres drained. Another advantage to be gained by draining this field would be that you could then change the 4 north fields to lie east and west. A lane extended straight north 80 rods from the farmstead would reach all 4 fields without a turn and would save 40 square rods of land and 40 rods of fencing.

The minor rotations are all right if they provide the crops needed, but while well arranged they are not as practical as they should be. Let us assume that they furnish the crops wanted as pasturage, grain, and clover. The 5-acre garden in your locality would likely be impractical, especially as you have a garden in the farmstead, unless garden be used very broadly, covering potatoes, sweet corn, or beans. The cost of fencing would be reduced if you would make a 4-year rotation by making 2 fields on each side of the farmstead instead of 3, and use but one rotation. I would suggest the following 4-year rotation for the four 7½-acre fields: First year, grain; second year, clover; third year, corn and rape; fourth year, corn and rape. The clover would be pastured by hogs or other stock. One or both of the two 7½-acre fields of corn and rape could be fed off by the hogs or sheep. This combination of 2 crops harvested by the animals themselves often yields a very handsome net profit per acre.

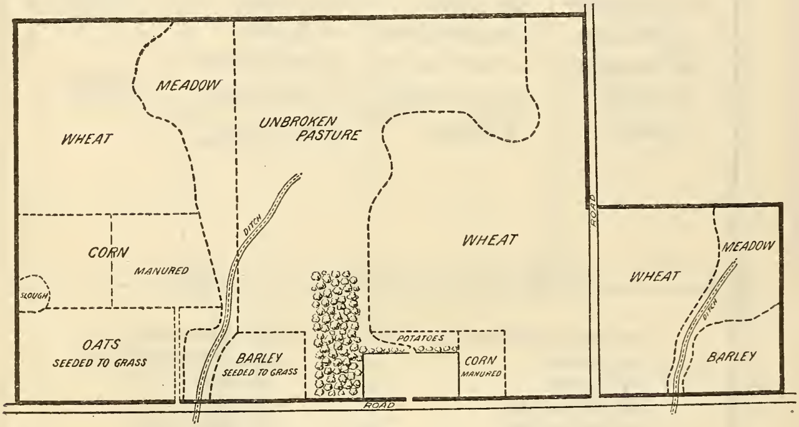

FIG. 50.—Ash Grove Farm. Original plan in 1901.

ASH GROVE FARM.

[Statement by F. B. Headley, figs. 50, 51, 52, 53, 54, and 55.]

THE STUDENT'S PLANS.

Ash Grove Farm is located in Book Lake Township, Renville County, Minn. The farm contains 280 acres, all of which can be cultivated. The rotations, as indicated in figure 54, provide 40 acres of hay, 40 acres of corn, and about 80 acres of pasture, also 20 acres of rape each fall for young stock. This should feed about 60 head of cattle, half of which will be milk cows. Six work horses and one roadster will be kept. The intention is to market about 30 hogs each year. Some wheat will be sold, but all other products will be fed on the farm. The small fields, K, M, and N, are intended for hog pasture.

INSTRUCTOR'S CRITICISM.

Mr. Headley's plans show how a farm may gradually be developed and the fences be erected while the complete plans are being put into operation. While these plans are excellent, the fields have been made smaller than necessary, and hence there is a waste of fence material. The plan projected in figure 54 shows the acreage and crops, as follows:

	Acres.		Acres.
Pasture	80	Wheat	65
Hay	40	Barley and oats	26
Corn	40		

By dividing the farm as indicated in figure 55 into six 40-acre fields, A, B, C, D, E, and F, and putting a 6-year rotation on the 6 large fields and a 6-year rotation on the 3 small fields, as indicated, he would have the average shown in Table XVI.

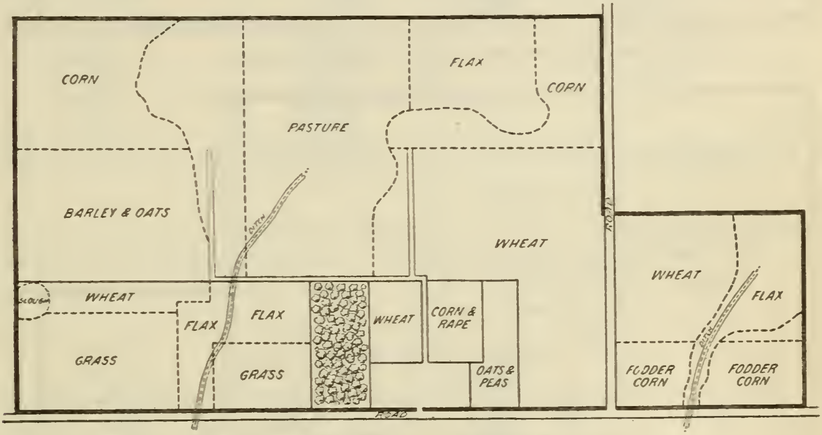

FIG. 51.—Ash Grove Farm. Transition plan in 1902.

TABLE XVI.—*Revised scheme of crop rotations for Ash Grove Farm.*

Year.	A.	B.	C.	D.
1905	Grass	Wheat	Corn	Corn, barley, and wheat.[1]
1906	do	Grass	Wheat	Corn.
1907	do	do	Grass	Wheat.
1908	Corn, barley, and wheat.[1]	do	do	Grass.
1909	Corn	Corn, barley, and wheat.[1]	do	Do.
1910	Wheat	Corn	Corn, barley, and wheat.[1]	Do.

Year.	E.	F.	G.	H.	I.
1905	Grass	Grass	Grass	Fodder	Oats.
1906	Corn, barley, and wheat.[1]	do	do	Oats	Fodder.
1907	Corn	Corn, barley, and wheat.[1]	Oats	Grass	Do.
1908	Wheat	Corn	Fodder	do	Oats.
1909	Grass	Grass	do	Oats	Grass.
1910	do	do	Oats	Fodder	Do.

[1] Rape with oats, barley, or wheat.

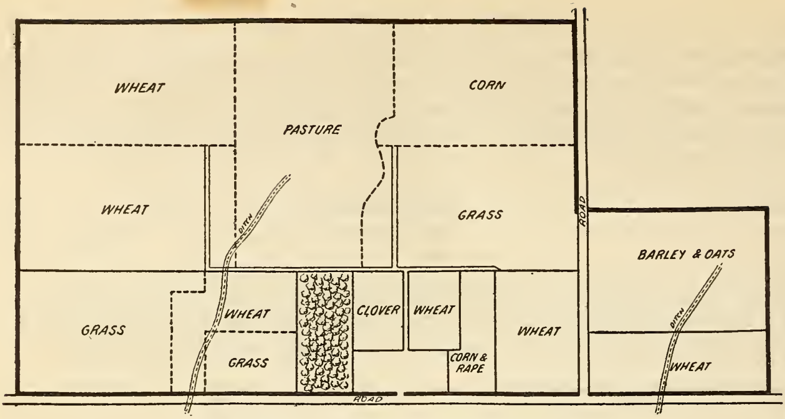

FIG. 52.—Ash Grove Farm. Transition plan in 1903.

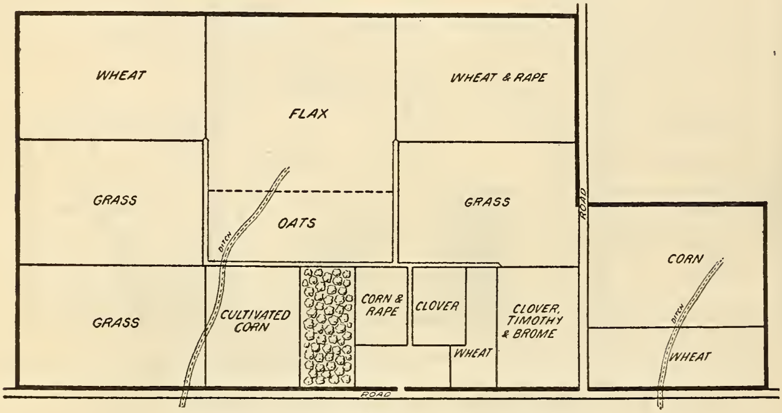

FIG. 53.—Ash Grove Farm. Transition plan in 1904.

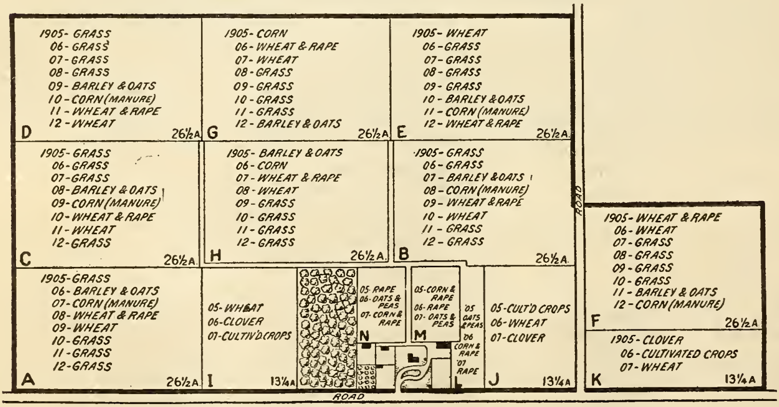

FIG. 54.—Ash Grove Farm. Key map to student's plan, 1905–1912.

Thus we get annually:

88 acres grass.	40 acres rape.
40 acres hay.	60 acres wheat.
48 acres corn.	28 acres oats and barley.

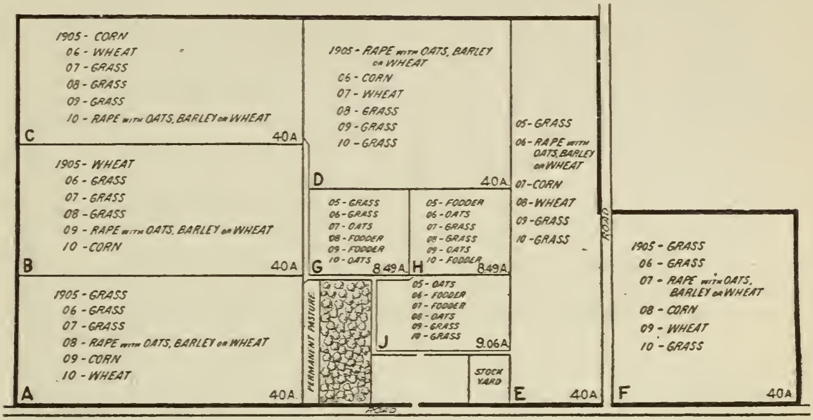

Fig. 55.—Ash Grove Farm. Key map to revised plan.

It requires 1,200 rods of fence, not taking outside fences into account, to inclose fields and lanes according to figure 54, while according to figure 55, 900 rods fences the fields just as satisfactorily and also gives more rape for autumn pasturage.

Pomme de Terre Farm.

[Statement by Mr. Hall, figs. 56 and 57.]

This 240-acre farm is near Morris, Stevens County, Minn. The land is now all tillable, as a large ditch was put through the west 80 last year. This is to be tiled the coming summer in order to have regular fields. The buildings are in good repair and consist of a house, barn, hog house, machine shed, and shop. The fields are divided as shown in figure 56. The farm heretofore has been devoted almost entirely to grain raising, little live stock other than the necessary horses for the operation of the farm being kept.

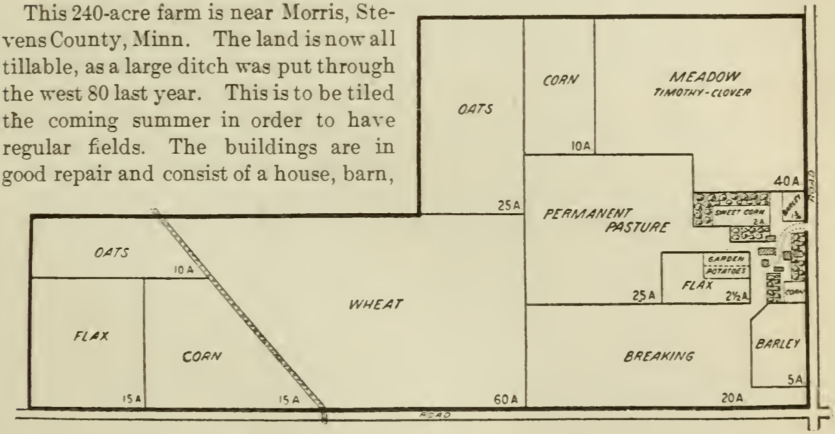

Fig. 56.—Pomme de Terre Farm. Original plan.

THE NEW PLAN.

No rotation has ever been followed, but one is planned, as in figure 57, that all grain and roughage may be fed to stock and not sold directly from the farm. It is estimated that the farm under this rotation will support 35 head of cattle and 50 sheep, also the product of 10 brood sows each year. A rotation on four 40-acre fields is to be as follows: First year, corn; second year, wheat; third and fourth years, meadow and pasture. There are two other rotations, one a 3-year rotation on three 20-acre fields: First year, corn; second year, grain, third year, clover. The other is a 4-year rotation on four 2½-acre plats: First year, corn; second year, fodder corn; third year, roots; fourth year, wheat.

INSTRUCTOR'S CRITICISM.

Your new arrangement of fields is very good, yet a simpler rotation would be likely to give you better satisfaction. Would suggest that you use the two 20-acre fields in the northeast corner for a 40-acre field, changing the rotation on your larger fields to a 5-year rotation instead of four, as follows: First year, corn; second year, grain; third and fourth years, meadow and pasture; fifth year, grain. This would give you 80 acres of grain in place of 40, would be a less radical change from your former system of cropping, and would probably pay better in your vicinity.

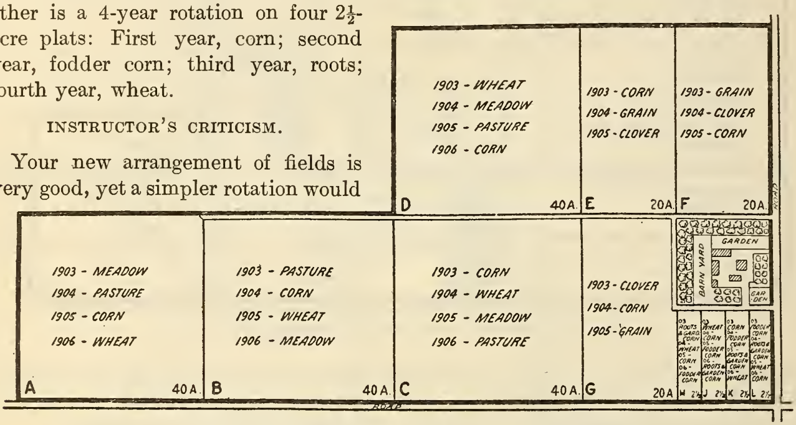

FIG. 57.—Pomme de Terre Farm. Key map to new plan.

The 4-year rotation on the small fields too rapidly reduces the vegetable matter in the soil. Would do away with the 4-year rotation, giving three 10-acre fields, east, southeast, and south of the farmstead, for the following 3-year rotation: First year, corn; second year, grain; third year, clover. Such cultivated crops as you desire to grow, as roots and potatoes, could be put in the cornfield in one of the other rotations.

5/14